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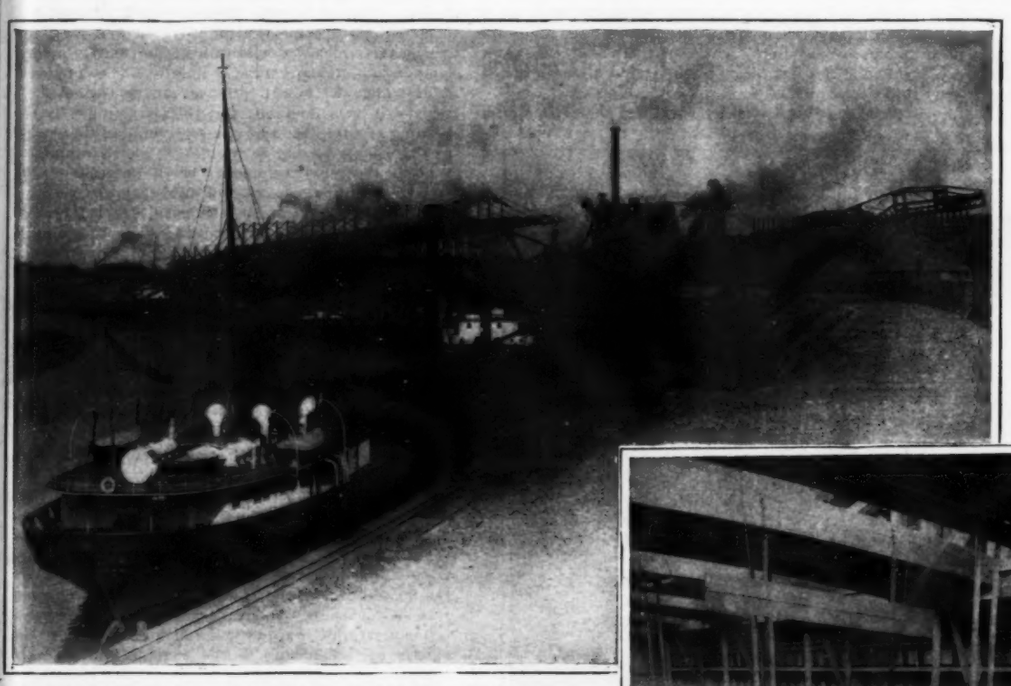
A NEW TYPE OF GREAT LAKE ORE STEAMER.

By Day Allen Willey.

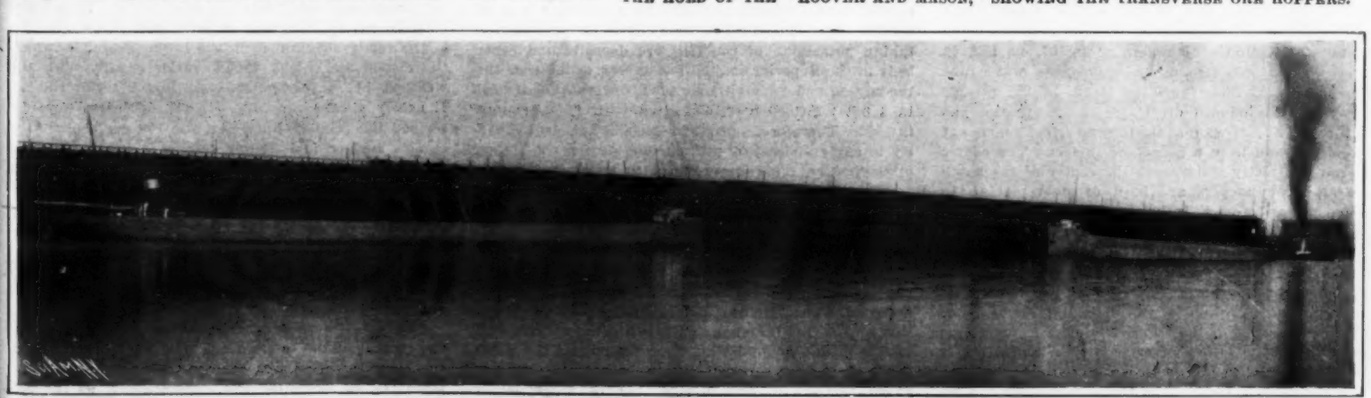
Ever since the shipments of iron ore from the Superior ranges to American furnaces have been made on an extensive scale, vessel builders on the Great Lakes have been trying to solve two problems. One is the construction of the largest ore carrier which can be built to enter the harbors where the ore is unloaded. The other problem is to design a vessel which can be unloaded in the least time and at a minimum expense for labor.

It is due to the consideration of these problems that the construction of steel vessels on the Great Lakes has made such remarkable progress, especially within the last decade—not only in the increase in dimensions, but also in design. In 1905 four steamers were completed for the ore-carrying service, the combined capacity of which actually equaled the total cargo capacity of the whole fleet of lake steamers which were in service twenty-five years ago. It seems almost incredible, but the later types of vessels will carry a far greater tonnage than any other craft which has been built for service on fresh water, either in America or any other part of the world. Such is their draft when completely loaded, that they could not enter the ports on Lake Erie where the bulk of the ore is discharged, for the capacity of each is nearly 15,000 tons. A clearer idea of their great size can be gained by comparing them with one of the newer cargo ships constructed for transatlantic service, such as those in the fleet of the White Star Line. The "Baltic" is the largest cargo ship afloat, measuring 725 feet 9 inches over all, 75 feet in beam, and 47 feet in depth of hold. The dimensions give the "Baltic" a freight capacity of 28,000 tons. Each of the four lake vessels referred to, however, will carry over 50 per cent of the tonnage of a ship the size of the "Baltic," though they are but 569 feet over all, 56 feet beam, and 31 feet depth of hold. As the vessels of the 1905 class are unloaded by such mechanical systems as the fast plant, the bridge tramway, and the Hulett shovel bucket, it would seem that the shipbuilders had reached the highest standard in the type of ore carriers; but even these steamers require more or less manual labor, since none of the mechanical unloaders will "clean up" the cargo, owing to the design of the hold. In removing the ore from one of these great floating tanks, for such they are, from five to ten per cent of the cargo usually remains. This must be shoveled into piles or "trimmed" by hand to place it in the reach of the mechanism. The time consumed in this labor equals a third of the time required to remove the entire cargo. The expense to the owners when a vessel is lying at the dock may be estimated, when it is stated that the ore carrier of the dimensions of the 1905



AN ORE STEAMER OF THE LATEST TYPE UNLOADING AT THE DOCKS.

THE HOLD OF THE "HOOVER AND MASON," SHOWING THE TRANSVERSE ORE HOPPERS.

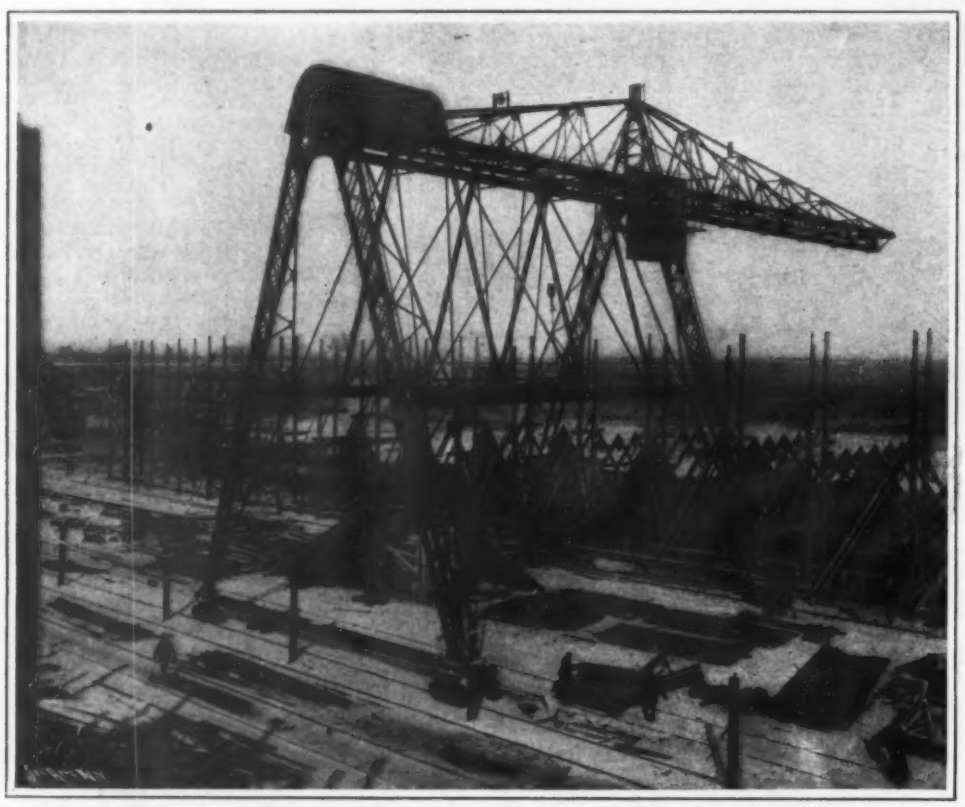


TWO 12,000-TON ORE STEAMERS AT THE DOCKS, DULUTH, MINN.

A NEW TYPE OF GREAT LAKE ORE STEAMER.

class averages nearly $300 per day for wages, insurance, fuel, and other outlay, even when moored at the wharf. As this freight is transported at a lower cost than any other cargo in the world when reckoned by the ton, it is necessary to reduce operating expenses to a minimum; and as already indicated, a considerable loss is incurred when it is necessary to employ hand labor for trimming.

Apparently, however, this problem has been solved by the construction of a new type of vessel, which may be called a radical departure in marine construction. One of the craft referred to has been in service for several months, and it is claimed that it can be loaded and unloaded at a smaller cost per ton of cargo than any which has yet been placed in commission on fresh water or salt water. In designing this type of vessel four points were taken into consideration: To construct a stronger vessel without increasing the weight of the hull, to have the entire cargo accessible immediately under the hatches to grab buckets, to minimize the floor space to be cleared up, to bring up the center of gravity of the cargo as far as possible. It is obvious that by this method of construction the work of unloading by mechanical means can be greatly facilitated, but there are several other advantages, one being that the hull is greatly strengthened, since the framework of the hoppers forms transverse bulkheads, which reinforce the upper portions of the craft. The arrangement of the hoppers is a new feature, and a radical departure from the latest type of construction. It permits a return to the standard



BUILDING A BIG CARGO STEAMER, SHOWING THE BOTTOM HULL PLATES AND THE ANGLE FRAMEWORK ATTACHED TO THE KEEL.

hatch covers, for it is unnecessary to use the patent coverings requisite in the 12-foot centered boats. The arch construction of deck support has also been replaced by deck beams.

The "Hoover and Mason," which is the vessel illustrated in the accompanying photographs, is not as large as the vessels of the 1905 fleet referred to. Her dimensions are as follows: 524 feet over all, 504 feet keel, 54 feet beam, and 30 feet molded depth. The power equipment consists of a quadruple-expansion engine with cylinder diameters of 18, 27, 40, and 42 inches by 62-inch stroke, and Niclausse water-tube boilers, 9 by 13 feet, providing steam at 250 pounds pressure, with induced draft and chain grates. The hoppers are 24 feet wide at the top and 6 feet 9 inches at the bottom and have a height of 13 feet. The center of each is directly underneath the center of the hatch opening. The hoppers are built of steel plates, the bottom plates being 5/8 inch in thickness to withstand the drop of the ore in loading, and are bent up at the sides, greatly adding to the strength of the general construction. The width of the flat portion of the hopper bottom was governed by the size of the largest shovels or grab buckets at the unloading docks. The angle of the sides of the hoppers is such as to incline the cargo to the center of each hopper, and make it easily accessible to the operation of the grab buckets. False plates from the shell of the ship run inboard between transverse hopper sides, completing the hopper.

One of the points made against the practicability of the transverse hopper construction was that the ore would adhere to the plates forming the inclined sides, and that the removal of this ore would necessitate the employment of shovelers. This difficulty has been overcome in the manner of loading. The spout of the chute from the dock pockets, instead of being directed against the sides of the hopper, discharges over its center, forming a conical pile, the large pieces falling by gravity to the outside circumference of the cone and resting against the hopper sides, while the fine ore settles in the center. As the ore is unloaded these lumps slide down the inclined sides, carrying the fine ore with them.

In the "Hoover and Mason" the hoppers form the tank top of the ship's water bottom, which is another departure from the more recent double-hull construction on the Great Lakes. The deck is supported by beams resting on the ridges of the hoppers. These come midway between the hatches and extend the full width of the ship, but from their location they do not interfere with the cargo in any way. Beams on either side of the hatches run continuously fore and aft of the ship, forming an excellent stiffening of the top chord of the truss formed by the sides of the vessel. The frames or ribs, instead of continuing unbroken into the water bottom, stop at the hopper tank top, to which they are attached, and continue again at a point inside the hopper. This design was necessary to secure absolutely tight construction of the water tank, and has not reduced the general strength of the ship's construction.

Since the vessel was launched, she has carried on a single trip nearly 10,000 tons of cargo, the actual quantity being 9,841 tons. Owing to the design of the hold and its accessibility, the actual cost of unloading this quantity of material was but $70—about seven mills per ton. Nowhere has such a record for the economical transfer of cargo been made.

The total tonnage of ore transferred by water from the Superior ranges during 1906 aggregated nearly 40 million tons. During 1905 the total quantity was 35 million tons. The United States Steel Corporation, in taking possession of the Hill ore deposits and other beds in the Superior region, has agreed to increase the tonnage mined year by year until during 1917 it will take out 8,250,000 tons, compared with 1,500,000 tons in 1907. Therefore, a fleet of vessels of sufficient capacity to carry at least 50 million tons during the season of navigation must be provided to transport the ore for this corporation and the other ore smelters. The expense of unloading this enormous quantity can be appreciated. Even estimating it at the minimum figures quoted, it would amount to no less than $3,500,000. Consequently, the importance of having vessels which can be completely unloaded by mechanical methods is apparent. The "Hoover and Mason," it is understood, was constructed largely as an experiment, to determine if this model would be an improvement on the other types of craft in service. In all probability, a fleet of cargo carriers of this design, but of much larger capacity, will be built as a result of its performances; for steamers carrying as large a tonnage as the 1905 class can readily be constructed after this design, although it is doubtful if any of larger dimensions will be built on the Great Lakes, owing to the depth of water in the ship canals and in the harbors of the unloading ports.

It is interesting in this connection to note the rapid expansion of vessel building on the Great Lakes, despite the large fleet which has been completed in the last ten years. During the last fiscal year, no less than 204 steamers and barges, aggregating 265,271 tons, were built on the lakes—63 per cent of the total marine construction of the United States during this period. In seven shipyards on June 30th there were planned or under way 32 vessels, aggregating 175,000 tons.

THE GREATEST ALTITUDES ATTAINED BY UNMANNED SOUNDING BALLOONS.

By DR. A. WAGNER.

SINCE the year 1900, in pursuance of an international agreement, balloons have been sent up monthly from most of the principal meteorological stations in Europe, for the purpose of investigating the conditions and phenomena of the atmosphere. Information of especial value has been obtained through "sounding balloons." These are small unmanned India rubber balloons, which are filled with hydrogen and carry instruments which automatically record air pressure, temperature, and relative humidity. The pressure, from which the height attained can be computed, is registered by a Bourdon tube, the temperature by the bending of a thin bar made by soldering together strips of two metals having very different coefficients of expansion, the relative humidity by the increase in volume by a hygroscopic mass of hair.

Most of these unmanned balloons attained heights between 6 and 10 miles, and a few ascended more than 15 miles. The greatest elevation, 18 miles, was reached by a balloon set free near Brussels, on November 5th, 1908. At this great elevation the air pressure was only 2/5 inch, so that only 1/76 of the mass of the atmosphere lay above the balloon. The balloon made a horizontal journey of 50 miles in 113 minutes.

As this ascension furnished a typical record of temperatures and humidity it will be described in detail. The temperature, which was 40 deg. F. at the earth's surface, decreased irregularly until a height of about 2 miles was reached. Below this level two reversals of the usual law of temperature were registered. The temperature rose from 39.6 deg. F. at an elevation of 623 feet to 42.6 deg. F. at 1,115 feet, and from 25.9 deg. F. at 4,986 feet to 34.2 deg. F. at 6,560 feet. Such inversions are of frequent occurrence in the lower atmospheric strata which are subject to terrestrial influences. In clear, calm nights an increase of temperature upward is found immediately above the earth's surface, owing to the effect of radiation in cooling that surface and the air in contact with it. A similar inversion often occurs above extensive and compact cloud layers.

Above the height of 2 miles the temperature falls very regularly as the elevation increases. In the ascension here cited, the thermometer registered 26.2 deg. F. at 1.9 miles, 6.1 deg. F. at 3.1 miles, —33.2 deg. F. at 5 miles, and —61.6 deg. F. at 6.2 miles. The lowest temperature, —89.7 deg. F., was encountered at a height of 8 miles. The height of the level of minimum temperature varies, according to the weather and the time of the year, from 5 to 8.7 miles, the minimum temperature itself from —40 deg. F. to —94 deg. F. Above 8 miles, in this ascension, the temperature increased very gradually with the elevation, becoming —84.6 deg. F. at 9.3 miles, —80.7 deg. F. at 12.4 miles, —80.5 deg. F. at 15.5 miles, and —80.3 deg. F. at the maximum elevation of 18 miles. A similar gradual increase of temperature upward is recorded by every balloon that reaches the great heights. No universally accepted explanation of this "permanent inversion" or "isothermal zone" has yet been given. It is probably caused by radiation of heat from the earth.

The relative humidity in the lower strata, in which the clouds are chiefly found, varies greatly with the weather, but at elevations exceeding 2 miles the air is nearly always very dry. In the ascension here described the relative humidity was 100 per cent at the earth's surface and 96 per cent at a height of 4,920 feet, which probably marked the upper boundary of the clouds. Thence it fell to 43 per cent at 1¼ miles and to 28 per cent at about 2 miles, and thereafter remained nearly constant up to the maximum height where it was 26 per cent.

In these balloon experiments the winds are studied by following the flight of the balloon with a theodolite and taking readings of altitude and azimuth at intervals. From these observations in combination with the records of the instruments attached to the balloon, the co-ordinates of the balloon's position at any instant can be computed and, consequently, as the balloon moves with the wind, the direction and velocity of the air current at any height can be determined.—Umschau.

SIGNALING TO MARS.

ITS IMPOSSIBILITY BY MEANS OF LIGHT.

BY EDGAR LUCIEN LARKIN, MT. LOWE OBSERVATORY, CAL.

ON September 23rd, 1909, Mars will come to opposition as shown in Fig. 1. The sun, the earth, and Mars will be near the same straight line. In Fig. 1 let the reader imagine that his eye is in the exact direction of Polaris, our present North Star. Go toward the Polar Star with an incessant speed of one mile per minute, during one hundred million years, take a huge telescope along, and turn to look this way. The power of the instrument would be taxed to see our sun as a minute star.

Let the wandering astronomer return during millions of years, ever on the lookout for the planets to come into view. Finally the earth and Mars, excessively small points, would be seen in the telescope. Then they would be observed moving from right to left, from west to east, counter clockwise, over through the figure 12 on the dial. Both worlds would be seen turning on their axes in the same direction as their orbital motion. The mean distance of the earth from the sun is 92,882,917 miles; and of Mars, 141,353,000 miles. The orbits are not circles, but ellipses. Thus when Mars is at *P*, or its perihelion, it is always 13,200,000 miles nearer the sun, than when at *A*, its aphelion. And when the earth is at *Q*, its perihelion, it is always 3,116,000 miles nearer to the sun than when at *R*, its aphelion. The entire orbit of the earth is represented by the plane of the paper, which plane also passes through the centers of the sun and the earth. The north pole of the earth points toward the reader's eye. The orbit of Mars is inclined to that of the earth as drawn in Fig. 2, by an angle of 1 deg. 51 min. 2 sec. On the day of opposition, Mars will

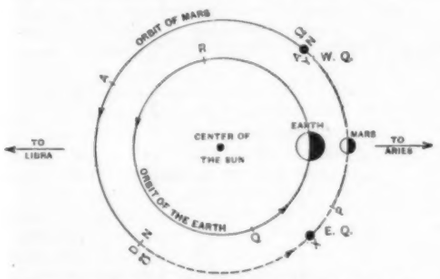


FIG. 1.—PLAN OF THE ORBITS OF THE EARTH AND MARS.

Drawn to scale of relative proportions. The dotted portion of the orbit of Mars is below, or south of the plane of the earth's orbit; and the continuous half is above it. The point A N is where Mars passes from south to north; and D N from north to south. September 23d being so near to the time of the autumnal equinox, both the earth and Mars will be near the first point of Aries as seen from the sun and as indicated by the arrow.

be on the south side of the plane of the ecliptic at a distance of 3,190,000 miles. In Fig. 1, the distance of Mars from the earth is 36,372,000 miles. Days and nights are shown in both worlds. But midnight on the earth is opposite to noon on Mars. Thus, the earth is totally invisible from Mars, since the Martians would be looking directly at the noonday sun. And no sunlight falls upon the hemisphere of the earth turned toward Mars. So it has actually been proposed to signal to Mars by means of electric light. Let an arc light be placed on each square yard of the night hemisphere of the earth. Even this display could not be seen from Mars in the fierce light of the sun. I watched the transit of Venus across the sun's colossal disk on December 6th, 1882, in a high-power telescope. It looked like a minute black dot against the mighty sun. Now had the entire hemisphere of Venus been illuminated by arc lights, this glow could not have been seen in the blinding sunshine. The diameter of Venus is 7,700 miles, while that of Mars is 4,200. If an opposition of Mars should occur when at a node ascending *A. N.*, or descending *D. N.*, Fig. 1, then to the Martians the earth would seem as a little jet black dot projected on the solar disk, and no quantity of electric light could be seen. To make and break circuits in order to signal the Morse telegraphic alphabet to our brethren over on Mars, when the lights are spread over half of the earth's surface, would be a feat in electrical engineering beyond all imagining. Hence, flashing electric light signals to Mars is utterly impossible.

Motions on orbits are indicated in direction by arrows. Before and after opposition of Mars, the earth appears to the inhabitants, if there are any, like a thin crescent as Venus does to us, when east and west of the sun. No signals could be sent from these narrow illuminated areas on the earth, because the people on Mars would still be looking in the general direction of the sun. The only times at which a ray from the earth could be seen from Mars are at its quadratures, or when Mars is in space, 90 deg. from the direction of the sun. Close attention must be paid to quadratures.

In Fig. 1, should Mars be at *X*, or at *Y*, it would be in quadrature, east at *X*, and west at *Y*. In Fig. 3 there is presented a greatly enlarged view of a quadrature. And that the signalers may begin work on

FIG. 2.—SHOWING INCLINATION OF THE ORBIT OF MARS TO THAT OF THE EARTH.

S is the center of the sun; E that of the earth, and M that of Mars at the instant of opposition in Fig. 1.

their solar mirrors, the coming quadrature, that of January 17th, 1910, is drawn in Fig. 4, in its true place on the orbit of Mars and its correct position relative to the earth and sun. The center of the sun only is indicated; for if drawn to scale in ratio with the earth, it would be 4 feet and 6 inches in diameter, and distant 489 feet. In Fig. 3 none living on Mars in broad daylight as shown can see the earth without a powerful telescope. The only areas on Mars whence a glimpse of the earth could be had with the unaided eye are the thin strips, lunes geometrically, turned slightly toward the earth a few days before and after instants of quadrature. These times of possible seeing the earth are for a few minutes before sunrise at any eastern quadrature as shown in Fig. 3, or a few minutes after sunset at any western. But at these instants it is also sunrise or sunset on the earth. Slight vapors or fogs in the atmospheres of either world will prevent momentary glimpses of signals. The quadrature of 1910 will place Mars at a distance of 108,000,000 miles from the earth. On a circle having this radius 1 sec. of arc is 520 miles. A mirror 1 inch in diameter carried to a distance of 3.25 miles will subtend an angle of 1 sec. Could this mirror be used here on earth as a telegraphic signal even at noon on a clear day?

Suppose that our good friends have telescopes so powerful that they can see an object 0.1 sec. in diameter at a distance of 108,000,000 miles. Then the reflector must be 52 miles wide. Human skill is now being taxed to the extreme in making a mirror 100 inches in diameter, in Pasadena, for the Mount Wilson Observatory. All the glass that could be made for centuries would be required to make a mirror 52 miles in diameter. And all the metal for mounting this giant reflector! It must be attached to an axis parallel to that of the earth, and this must be turned by means of a gigantic clock, regulated to accurate sidereal time. Steel shafts in ocean steamships would be as spider threads in comparison to the axis of the reflector, or with the axes of the enormous cog-wheels. How many million tons must the clock weights weigh?

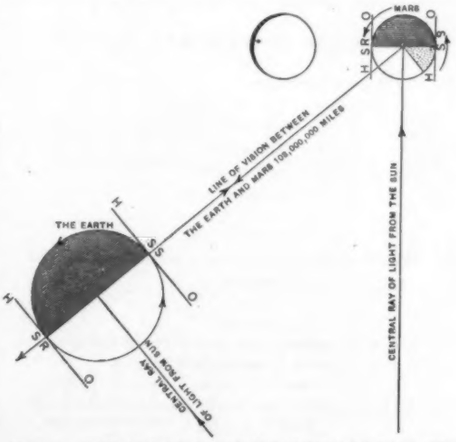

MARS
LINE OF VISION BETWEEN THE EARTH AND MARS 108,000,000 MILES
THE EARTH
CENTRAL RAY OF LIGHT FROM THE SUN
CENTRAL RAY OF LIGHT FROM THE SUN

FIG. 3.—ENLARGED VIEW OF THE EARTH AND MARS AT EASTERN QUADRATURE, AS DRAWN IN FIG. 4.

Mars is on the meridian at sunset shown on the earth at S S. All lines on the earth and Mars marked H, O are horizons. The unilluminated area on Mars 1, 2, 3 is enormously exaggerated owing to inability of showing the sun in the cut. The strip upon which no light falls at quadrature is very narrow and extends nearly from pole to pole on Mars. The effect is to cause Mars to assume a gibbous form like the moon a short time before and after the full phase. Flat surfaces here represent spheres. And on this account the part of Mars dotted is invisible from the earth.

A ray leaving the revolving mirror must be reflected parallel to the axis of the earth and fall upon a stationary mirror whose work is to send the beam to Mars. Thus a beam of light from the sun must traverse the air layer twice and be reflected twice, only with great loss of intensity. Our brethren on Mars must also mount their huge telescopes on axes parallel to that of the planet, and drive them by means of accurate clocks. In Fig. 3 the earth's surface at *s s* moves, at the equator, 1,040 miles per hour, and on the equator of Mars with a velocity of 538 miles per hour at *S R*, in the opposite direction, a combined motion of 1,578 miles per hour, which must be allowed for by the Martian and terrestrial clocks. Let the mirror cost $5,000,000,000 and the clock an equal amount. Then the outfit could be used during a few minutes before sunrise and after sunset on Mars. And these minutes only at times of quadratures. But then a thin fog might come up at any time. How hopeless to signal Mars by means of light when at all other points in its orbit, when its day side is always turned earthward! How make dots and dashes over a mirror 52 miles wide or one mile or the hundredth of a mile?

PROGRESS WITH THE ELECTRIC FURNACE.

THE present status of the electric furnace as an instrument for the refining of steel is indicated by the following figures compiled by the Electrochemical and Metallurgical Industry:

"There are now in operation or course of erection 19

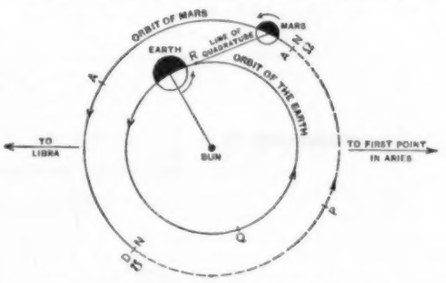


FIG. 4.—QUADRATURE OF MARS ON JANUARY 17, 19 0

The plan of orbits is the same as in Fig. 1. The relative positions of the sun, earth and Mars are given, Mars being 90 deg. in direction from the sun. By comparing with Fig. 1 the distances traversed by both planets since opposition can be determined.

Héroult furnaces of an aggregate charge capacity of 63,300 kilogrammes, and 5 Héroult furnaces the capacity of which is not definitely decided; 11 Stassano furnaces of an aggregate capacity of 16,900 kilogrammes; 8 Girod furnaces with a capacity of 34,000 kilogrammes; 10 Kjellin induction furnaces with a capacity of 21,500 kilogrammes, and 10 Roechling-Rodenbauser modified induction furnaces with a capacity of 21,200 kilogrammes. The above figures include 2 Héroult furnaces in this country, the other 22 being abroad. The furnaces of the other types are all in Europe. There are, however, some small Colby induction furnaces in operation in this country; one, chiefly for demonstrating purposes, in Niagara Falls. Two things are evident from the above figures: First, that electric steel refining is beyond the experimental stage. Second, that this country has been lagging in this development behind Europe."

The by-product coke oven and the blast furnace gas engine have had the same evolution that is now indicated for the electric furnace in steel making—a period of extensive development in Europe and a belated adoption in the United States of the results of European pioneering. That the inroad upon the open-hearth furnace prophesied by Mr. Schwab at the tariff hearing at Washington recently will come in the next ten years may be doubted, but there are already indications of a coming appreciation of the value of the electric furnace as an auxiliary of the open-hearth furnace and the converter for refining steel in compliance with the increasing demand for improved quality. Further confirmation is at hand, also, of what has been regarded recently by the friends of the electric furnace as particularly significant, namely, that the electric furnace is more and more being developed from within the steel industry, whereas most of the work thus far has been done by electrochemical engineers having little or no connection with that industry.—Iron Age.

TESTING GAS ENGINES AND MOTORS.*

SOME RULES FOR ENGINEERS.

BY E. S. FRASH.

BEFORE running a test it is always best to run the engine light for a short time in order to limber it up, especially if it is a new one. Preliminary tests should first be run to determine the best loads to carry and, in making automobile motor tests, the most advantageous timing of the spark and the speeds for smooth running should also be determined by experiment.

A record blank for keeping memoranda of tests run should be provided. After a certain test, simply check the test run. This plan gives one a graphic result sheet which shows at a glance all the tests that have been run.

The running log for a motor test should contain the following items:

1. Number of the test.
2. Time.
3. Pounds of gasoline or kerosene used.
4. Cooling water.
   (a) Initial temperature.
   (b) Final temperature.
   (c) Weight of water circulated during test.
5. Revolutions per minute of motor.
6. Weight in pounds on the brake arm, *W*.
7. Length of brake arm, in feet, *L*.
8. Timing of ignition.

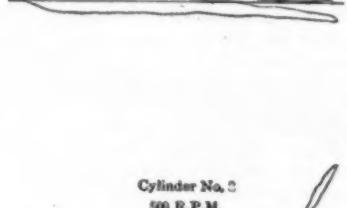
The average length of a short test should be about thirty minutes, with readings every five minutes.

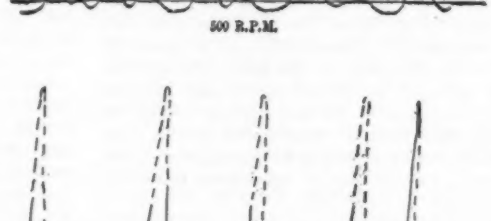
FINAL RESULTS OF MOTOR TESTS.

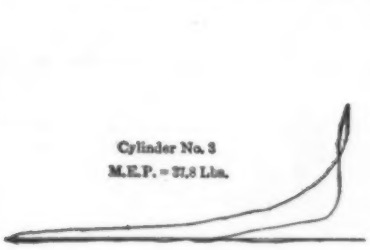
From the data taken on the running log of a motor test one should record the following direct and derived results:

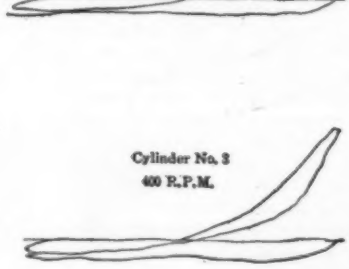
1. Running test number (from log).
2. Duration of test in minutes (from log).
3. Angle of advance of spark (from log).
4. Revolutions per minute of motor (from log).
5. Brake horse-power =
$$\frac{1904 \times L \times W \times \text{R. p. m.}}{10{,}000{,}000}$$
6. Pounds of gasolene per hour =
$$\frac{\text{Pounds used} \times 60}{\text{Duration of test}}$$
7. Pounds of gasolene per brake horse-power-hour =
$$\frac{\text{Item 6}}{\text{Item 5}}$$
8. B. t. u. of gasolene per pound (from maker).
9. B. t. u. supplied to engine per hour =
Item 6 × Item 8.
10. B. t. u. supplied per brake horse-power-hour =
Item 7 × Item 8.
11. Initial temperature of jacket water.
12. Final temperature of jacket water.
13. Pounds of jacket water circulated during test.
14. Pounds of jacket water per hour =
$$\frac{\text{Item 13} \times 60}{\text{Duration of test}}$$
15. B. t. u. absorbed by jacket water per hour =
(Item 12 — Item 11) × Item 14.
16. Thermal efficiency in percentage =
$$\frac{2545.2 \times 100}{\text{Item 10}}$$
17. Heat lost to jacket water, in percentage of supplied heat =
$$\frac{100 \times \text{Item 15}}{\text{Item 9}}$$

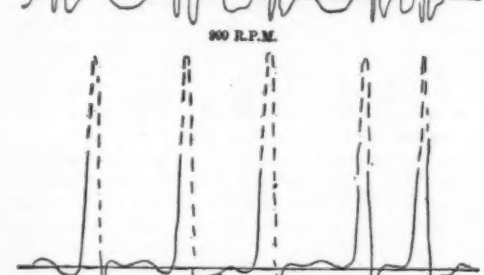
The heat value (B. t. u. per pound) of the gasolene may be ascertained from whoever supplies it, as a rule. If this cannot be done, a sample of the fuel should be tested by someone experienced in the use of calorimeters made for such work. In the absence of reliable information on this subject, the heat value may be estimated at 19,000 B. t. u., but this assumption makes the results of the test a little uncertain.

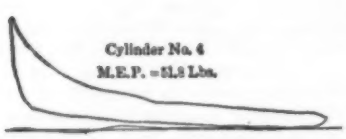


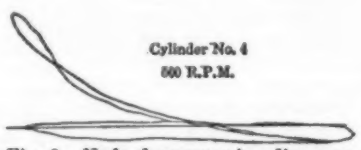












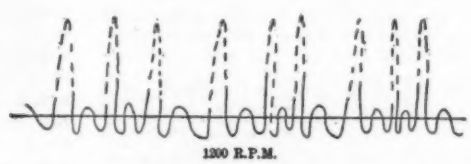


Fig. 1.—Closed diagrams taken at 500 R. P. M., with 60 pounds on brake. Scale 20 pounds per inch.

Fig. 2.—No-load compression diagrams. Scale 30 pounds per inch.

Fig. 3.—Continuous no-load compression diagrams. Scale 80 pounds per inch.

TESTING GAS ENGINES AND MOTORS.

Lower power tests should be of about fifteen minutes' duration, taking readings every three minutes. High power tests may be reduced in length to five or ten minutes' duration, taking readings every one or two minutes, respectively. The longer the test, the less chance of error.

The running log of a stationary gas-engine test should contain the following items:

1. Number of test.
2. Time.
3. Revolutions per minute of engine.
4. Room temperature.
5. Barometer reading.
6. Gas.
   (a) Cubic feet used for test.
   (b) Temperature.
   (c) Pressure.
7. Cooling water.

* Power and the Engineer.

FINAL RESULTS OF GAS-ENGINE TESTS.

For the Prony-brake test, such items as do not pertain to gasolene in the motor test also apply to a gas-engine test. Or the gasolene record can be used by substituting standard gas per hour for gasolene.

Standard gas per hour =
$$\frac{T_s P_1 V_1}{P_s T_1}$$

where

T_s = 460.7 + 62 = 522.7 deg. F. (absolute + standard temperature),

P_1 = Barometer reading + pressure of gas in pounds — 14.7; 27.71 inches of water at 62 deg. F. = 1 pound pressure per square inch,

V_1 = Cubic feet of gas used,

T_1 = 460.7 + temperature of gas,

P_s = 14.7 = one atmosphere or the pressure in pounds per square inch at sea level.

INDICATOR TESTS.

So far the discussion of tests has been confined to the Prony-brake test, but the field of engine investigation is immensely widened by the use of the indicator. Following is a description of the salient features of tests made by the writer on a well-known gasolene engine in the testing room of Purdue University; these tests can be very easily duplicated on any gas

engine. The machine referred to was a four-cylinder four-stroke-cycle, water-cooled engine, rated at 30 to 35 horse-power and designed for a maximum speed of 1,600 revolutions per minute. The compression was rated at 75 pounds at 200 revolutions per minute.

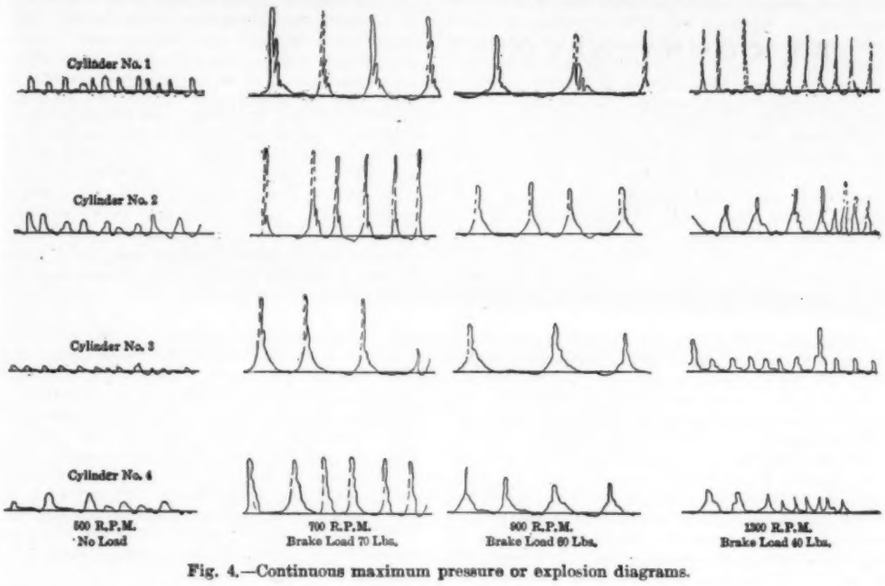

Cylinder No. 1
Cylinder No. 2
Cylinder No. 3
Cylinder No. 4
500 R.P.M. No Load
700 R.P.M. Brake Load 70 Lbs.
900 R.P.M. Brake Load 60 Lbs.
1300 R.P.M. Brake Load 40 Lbs.

Fig. 4.—Continuous maximum pressure or explosion diagrams.

The object of the tests was to study the indicated power and cylinder conditions of the motor. Besides a Prony brake, indicators were used. Two indicators were used and cards were taken simultaneously first from cylinders No. 1 and No. 3, and next from cylinders No. 2 and No. 4. The indicators were attached directly to the cylinders by replacing the priming-valve caps by caps tapped to take the indicator fitting.

Various diagrams were taken, such as ordinary closed diagrams, Fig. 1; closed compression diagrams, Fig. 2; continuous compression diagrams, Fig. 3; maximum explosion pressures, Fig. 4; speed compression diagrams, Fig. 5, and hand-cranked compression diagrams, Fig. 6. The closed diagrams of Fig. 1 were taken just as ordinary gas-engine cards would be taken. In taking the compression cards in Fig. 2, the ignition circuit to the cylinders being tested was opened, causing the motor to run on the other two cylinders. Otherwise, the diagrams were taken in the same way as those in Fig. 1. In taking the remaining diagrams, the cord from the indicator drums was disconnected from the engine and the cord pulled by hand.

From the diagrams the following conclusions were drawn:

On comparing the diagrams of Fig. 3 from the different cylinders, it is evident that there is a large variation in compression pressure. This variation was no doubt largely due to the condition of the valves, and partly to leakage past the piston. The engine was designed to have 75 pounds compression at 200 revolutions per minute, but as the diagrams show, it fell short of this during the tests. The maximum explosions and power fell short in the same proportion.

From the diagrams in Fig. 4 it is obvious that the explosion pressure was not the same in all cylinders. Cylinder No. 3 was somewhat irregular and there are not enough data at hand from which to draw definite conclusions as to the cause. Cylinder No. 4 had a comparatively low explosion pressure, which is explained by the fact that it had low compression.

The diagrams at 500 revolutions per minute were taken while cylinders Nos. 1 and 4 were in bad condition. No. 3 was having spark trouble and its low explosion pressure was not due to its valves at this time. The diagrams taken at 700, 900, and 1,300 revolutions per minute, used when taking explosion cards, show the effects of valves in poor condition very clearly. The valves of cylinder No. 1 were reground, as before stated, while No. 4 was left in its poor condition for a comparison.

The cards here shown tell the same old story, that no matter how good the ignition system, the valves, the real backbone of any engine, must be properly ground and cared for in order to obtain the maximum efficiency of the engine.

From the compression diagrams, Figs. 5 and 6, it is evident, as indicated by Fig. 2, that the engine had not the designed compression, for at 500 revolutions per minute the compression was much less than 75 pounds, and the compression decreased as the speed increased. Comparing the cylinders, the diagrams show that the cylinders work more uniformly as to compression than as to explosion; the probable reason is that the spark coil did not seem to work quickly enough on high speeds.

Fig. 7 illustrates the effect of speed upon efficiency. The curves were plotted from the results of tests on the same motor which gave the preceding indicator diagrams, and show quite conclusively that while the engine was capable of increased output by running it at higher speeds, the best speed for normal running was 900 revolutions per minute.

RESULTS OF GAS-ENGINE TEST AND METHOD OF WORKING THEM UP.

From a running log such as that previously suggested and the indicator diagrams, one is able to obtain the following results:

1. Running test number.
2. Duration of test, in minutes.
3. Revolutions per minute.

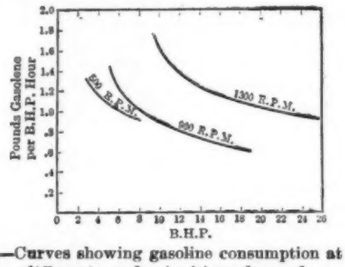


Fig. 7.—Curves showing gasoline consumption at three different speeds; ignition advanced.

4. Brake horse-power =
$$\frac{1904 \times L \times W \times R.p.m.}{10{,}000{,}000}$$
5. Explosions per minute.
6. Mean effective pressure (from indicator diagram).
7. Indicated horse-power =
$$\frac{\text{Item 5} \times \text{Item 6} \times \text{Piston area} \times \text{Stroke}}{33{,}000}$$
8. Friction horse-power.
9. Mechanical efficiency = Item 4 ÷ Item 7.
10. Pressure of gas in inches of water.
11. Temperature of gas degrees Fahrenheit.
12. Cubic feet of gas used during test.
13. Cubic feet of gas used per hour.
14. Standard gas per hour.
15. Standard gas per indicated horse-power-hour = Item 14 ÷ Item 7.
16. Standard gas per brake horse-power-hour = Item 15 ÷ Item 4.
17. B. t. u. per cubic foot of standard gas.
18. B. t. u. supplied per indicated horse-power-hour = Item 15 × Item 17.
19. B. t. u. supplied per brake horse-power-hour = Item 16 × Item 17.
20. Initial temperature of jacket water.
21. Final temperature of jacket water.
22. Weight of jacket water circulated during the test.
23. Weight of jacket water per hour.
24. B. t. u. absorbed by jacket water per hour = (Item 21 — Item 20) × Item 23.

HEAT BALANCE.

25. Heat equivalent of work = 2,545 × Item 4 ÷ Item 19.
26. Heat equivalent to engine friction = $\frac{2{,}545 \times \text{Item 8}}{\text{Item 19}}$
27. Heat to jacket water = $\frac{\text{Item 24}}{\text{Item 14} \times \text{Item 17}}$
28. Heat to exhaust and radiation = 1 — (Item 25 + Item 26 + Item 27).

A method for surface hardening structural steel and steel rails is described in the Mechanical Engineer. The principle whereby this is accomplished is as follows: The steel ingot, when stripped from the mold, is inclosed in a receptacle lined with brick, the receptacle being about eight or ten inches larger than the ingot placed in it. Space is left between the ingot and the sides of the chamber, and when the ingot has been lowered centrally into the receptacle, the intervening space between the hot ingot and the sides of the receptacle is filled as rapidly as possible with dry powdered carbon or other carbonaceous material. This material is rammed in between the ingot and the walls, and when the receptacle is completely filled, the ingot is allowed to remain covered for a length of time depending on the amount of carbon to be absorbed by the surface. Several hours as a rule is necessary for obtaining the required results. The carbon penetrates into the surface of the steel ingot, and the whole process may be compared with the case-hardening of mild steel parts. The carburized ingot, when removed from the receptacle, is again heated and rolled into a structural shape, the finished article now presenting a hardened surface. It is stated that if it is desirable that only a part of the outer surface of the ingot should be hardened, so that when rolled down, the harder part may form the head of a steel rail, for instance, the part forming a web or flange still remaining soft, the hot ingot may be put into a receptacle, and suitable division pieces inserted so that carbon may be brought into contact only with the part required to be hardened. This process has been developed by Mr. Benjamin Talbot, formerly of Phoenixville, Pa., who is now living in England.

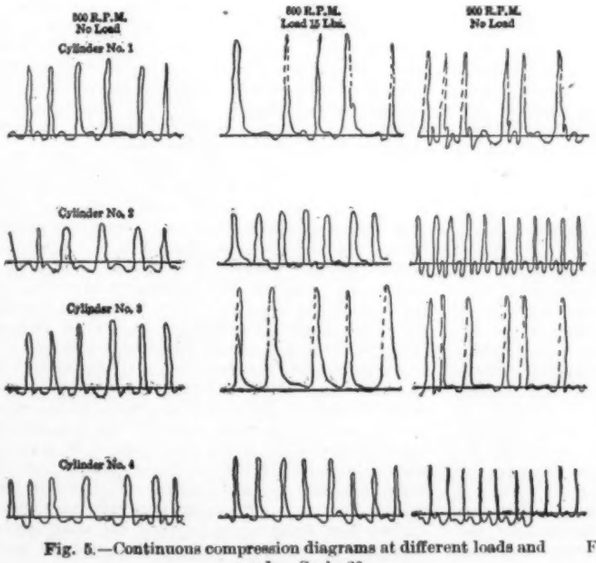


Fig. 5.—Continuous compression diagrams at different loads and speeds. Scale 20.

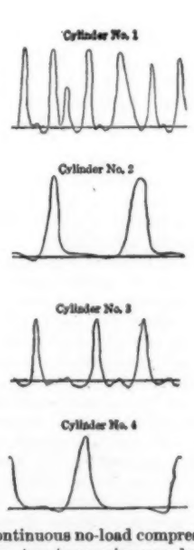


Fig. 6.—Continuous no-load compression diagrams, turning engine over by hand. Spring 20.

TESTING GAS ENGINES AND MOTORS.

THE NEW TELEFUNKEN TELEGRAPH.

A COMBINATION OF THE ARC AND SPARK SYSTEMS.

BY COUNT ARCO.

SUMMARY.—In this article the author describes a new system of wireless telegraphy, which is a compromise between the "spark" and the "arc" systems. Technical details of the equipment used are not given, but its practical and technical advantages are fully discussed. Among these are that the use of small antennæ is possible, a high efficiency is obtained and large powers can be employed, while electrically the arrangement is much more free from disadvantages than are the older systems. There is very great freedom from disturbance, and messages can be made quite "private," while the signals are transmitted as clear musical tones.

After it had been discovered that by means of the Poulsen arc it was possible to generate undamped oscillations of considerable energy, several scientists, especially those of a theoretical turn of mind, were inclined to lay too much stress on the advantages of this system, and the opinion was expressed in several quarters that undamped oscillations obtained from arc lamps would replace the other methods of generation within quite a short time. Practical men spoke against this enthusiasm, and drew attention to the numerous disadvantages present in the new system. To-day, scarcely three years after this period, it cannot be denied that the warning of the practical men was justifiable, and that the disadvantages of the arc lamp are even greater than the greatest skeptics thought. Not only from the practical point of view has the system been found disadvantageous, on account of the heavy upkeep and the many complications, but from a purely electrical point of view as well the position is the same. Of the energy generated at the sending end only a small fraction—at most one-tenth—is converted into electrical oscillations. For this reason both apparatus and machinery must be large and heavy. Moreover, the theoretical advantage—great freedom from disturbance from other stations and from atmospheric effects—is not obtained in practice.

Within the last year the Telefunken Company have designed a new system which is a compromise between the spark system of Marconi and that known as the undamped oscillation system. This new system is known as the "singing spark" (*tönende Funken*) system.

As regards the technical peculiarities of the new system, it may be said that it depends on spark methods, which in themselves depend on the principle published in December, 1906, by Prof. Max Wein and called by him "Stosserregung." This name has been changed by the Gesellschaft für Drahtlose Telegraphie to "quenched spark" (*Löschfunken*). This principle has been so perfected by the company that the sparks follow each other equally and regularly; so regularly, in fact, that they give out a clear musical tone, and to this system the name of "singing spark" has therefore been applied.

The first two types of station constructed by the company are: (I.) A ship or land station having a capacity of from 0.5 kilowatt to 2 kilowatts, and suitable for both large and small ships as well as for portable military stations. It has a radius of action of 62½ to 500 miles both to land stations and ships. (II.) The largest ship station at present erected, having a capacity of from 8 kilowatts to 10 kilowatts. With this type it will be possible with standard ship antennæ, under favorable conditions, to transmit 1,875 miles, a distance which has never before been reached from ship to ship. The same station is also suitable for work on land with correspondingly larger antennæ.

The practical and technical advantages of the new system over the older spark methods, as well as over the undamped arc oscillations, are summarized in the following paragraphs:

Singing sparks allow the work to be carried on with considerably smaller antennæ than do the usual wireless systems. The reason for this lies in the speed with which the sparks follow each other in the secondary circuit, thus making it possible to transmit greater power from the antennæ at a smaller maximum voltage than formerly. For this reason the new system is specially suitable when it is necessary to transmit over long distances with small antennæ. Theoretically this should also be the case when arc lamps are used, as for a given amount of energy the voltage lost in the antennæ is a minimum. Practice, however, has shown that with arc lamp installations the maximum height of mast must be employed, say, from 300 feet to 330 feet, while with the new system the same distance can be covered with masts about half this height. The reason for this contradiction between theory and practice is explained by the fact that the nominal oscillation energy from the arc lamp can only be generated when the wave length is very great, which means high antennæ. On the other hand, singing sparks work as well with the smallest as with the greatest wave lengths.

Singing sparks allow a high machine efficiency to be obtained, for, according to the size and suitability of the apparatus, from 50 to 75 per cent of the machine output can be changed into energy at the antennæ. With the old spark systems the maximum figure was 20 per cent, and in the arc lamp arrangement 10 per cent. In places where current for working the station has to be specially generated, this superiority obtained by using singing sparks will lead to a considerable decrease in the working costs. Further, it is specially advantageous where questions of weight and volume have to be considered, since in small ships and portable stations with this system the power and weight for an equal range is only about a quarter that needed for arc lamp stations. On account of this great efficiency another advantage arises. The wear and breakdowns of the apparatus are small, because of the small heat losses present, while regulation of the spark length, or of any other important part, of the new sender is hardly ever necessary. On this point Dr. Kiebitz has remarked that "in the singing spark system we may have a final solution to the problem of high frequency generation."*

With the new system it is possible to build senders as large as may be desired without any such limitations (e. g., in the wave length) or difficulties (e. g., in the constancy of the oscillations) as occur when a large amount of energy is transmitted. The new system behaves quite like the spark method, in which power as great as 100 kilowatts can be transformed into oscillations (though at a very low efficiency). It works better than the arc method of generation, for in this system if a large amount of energy is used, there not only is excessive damping on the long wave lengths, but irregularities of many kinds creep in, because at very high voltages and currents an arc lamp is unsteady, and the great development of heat gives rise to a rapid burning away of the electrodes. As, moreover, these inconstant conditions in the arc have an influence on the frequency the system is put at a still further disadvantage. Such alterations are much more likely to occur at large stations, and it has been up to date impossible to install this method of working for plants of large size.

The sender in the singing spark system is almost as noiseless in its working as is the arc lamp.

The sender transmits only one wave, and is thus different from the spark sender, which transmits two coupled waves. This fact marks a great step forward, as the receiver is able to utilize the total sender energy, and, owing to the disappearance of the two coupled waves, multiple telegraphy is made much more easy. Under such conditions numerous stations can work undisturbed close to each other.

The wave sent out by the singing spark shows a very small damping, viz., between 0.08 and 0.025, thus enabling a very sharp tuning and great freedom from disturbance in the receiver to be obtained. The freedom from disturbance may, according to circumstances, be much greater than that obtained with undamped oscillations. It varies, under conditions to be hereafter described, from 2 to 5 per cent.

These singing oscillations remain absolutely constant and are independent of the arrangement and mechanical properties of the spark gap and very much greater freedom from disturbance can be obtained than with the arc lamp. In the latter the greatest freedom is theoretically from ½ to 1 per cent, because the frequency does not depend upon the electric constants of the circuit alone, but on the arrangement, length, and properties of the arc. So long as the principle of generating undamped oscillations has to depend for its frequency on so variable a value as an arc lamp, ideal freedom from disturbance will never be obtained. In spite of the control of the resonance by means of a wave measurer, the frequency of the arc lamp alters, and a choice has to be made at the receiving end between a highly untuned receiver, whose intensity constantly varies so that certain telegraphic working is difficult, and a receiver very slightly free from disturbances, in which the total employment of the resonance is renounced so that the range is reduced. Arc lamp practice requires that the latter method should be chosen. The real freedom from disturbances of undamped waves reaches only 5 to 6 per cent, and even this, from the fact which we mention below, is seldom obtained in practice.

The freedom from disturbances of 2 to 5 per cent obtained with singing waves may be understood by considering the following example: At the three angles of an equilateral triangle, *ABC*, three stations of equal power are placed, *A* and *B* being fitted with senders and *C* with a receiver. *C* can then, as desired, receive from *A* or from *B* when these have a difference of wave length of only 5 per cent. This condition depends on the fact that the distance apart of the three stations is as great as possible for the energy available, so that the telegrams will not arrive at *C* with very great intensity. If the distance apart of the three stations is reduced to one-half that mentioned above the senders at *A* and *B* can be made different by 3 per cent instead of 5 per cent, or by still smaller differences if the distances are still further altered. When speaking of freedom from disturbances, it is understood that the percentual differences which must necessarily be present at the maximum range are included.

Singing sparks allow a large scale of oscillations to be obtained, while with the old spark stations only certain fixed waves could be sent out; and, on account of electrical resonance, the scale of waves could only differ from the fundamental of the antennæ by about double the wave length. It is possible with this new system to obtain oscillations of wave lengths four, five, and even six times as long as the fundamental, though the range gradually decreases. This new system behaves exactly like the arc lamp system, except that the singing oscillations have the advantage that antennæ with very small fundamentals can be used, while with arc lamps these large scales of oscillations can only be employed with very high masts and long antennæ. The generation of the different oscillations can be obtained on the new system in a very simple way by using the regulating arrangement known as a variometer, and without the use of a wave measurer being generally necessary.

As mentioned above, the system allows very short oscillations to be transmitted. Short oscillations are, however, more absorbed on the way, though this apparent disadvantage is often a very great advantage from the military point of view. Suppose a message is sent with very short oscillations to a station 50 kilometers away, and is received with great intensity. The enemy at a distance of, say, 100 kilometers, would scarcely be able to pick up anything, even with the most delicate instruments, while the behavior of longer waves is quite different. Over open country, distances of over 200 kilometers to 300 kilometers can be covered by these waves, and they possess the advantage that a listener a little farther off cannot understand anything. It is, further, possible by using quite short waves to remove the instrument from the operations of large stations which only work with long waves. The use of short waves, also, predicates an extraordinarily high antennæ efficiency, as, on account of the more speedy transmission of energy with short waves, the maximum energy for a given antenna can be increased.

The system of singing sparks allows, under all circumstances, unlike the arc lamp, full freedom from disturbance, as the intensity of the oscillations can be regulated in a most simple fashion between wide limits. Even with a station having a range of several thousand kilometers, the intensity can be so reduced that telegrams will only be heard over a distance of 100 kilometers, and, further, "tapping" by unauthorized persons is made very difficult and the freedom from disturbances is greatly increased. Take, as an example, that given above. Suppose the range of a sender, say at *B*, to be reduced to one-hundredth of the distance from *B* to *C*, a 5 per cent freedom from disturbance will become, perhaps, 30 per cent, if *B* does not reduce its sending intensity. To do this is quite possible with the new system, while regulating an arc lamp on a small current leads to an unsteadiness of the flame and makes the apparatus work badly. It is, therefore, not very correct to speak of a freedom from disturbance of 5 per cent with the arc lamp when in many cases a freedom from disturbance of only 20 to 30 per cent is really obtained.

Perhaps the greatest advantage of the new singing spark is the fact that the signals are transmitted as clear musical tones. Musical sparks have already been often proposed and also partly developed, but the tone cannot be made clear, and only by the absolute clear-

* The Electrician.

* See Elektrotechnische Zeitschrift, 1909, No. 10, page 222, *et seq.*

ness and regularity of sound were the above results obtained with the new system. With audible working from the old spark stations the signals of the telephone were received as ticks. Each time the spark passed the membrane moved, while with the arc lamp similar noises were also obtained. Similar phenomena are noticed with atmospheric discharges in receivers at these stations, and with this arrangement the working was often disturbed in spark stations; but the conditions were much worse in arc stations, as the noises from atmospheric disturbances are very much like those given by the latter type of working. It is, however, quite different when receiving the sound from the musical spark system. However numerous and strong the discharges may be, an even slightly skilled telegraphist can distinguish them by their singing tone. The sound, if it is truly musical, can be clearly heard even if it is very weak. It may be said that for the first time since the invention of wireless telegraphy a system has been obtained which enables telegraphic work to be carried on through the heaviest atmospheric disturbances, and up to the limit when the detector would break down under the atmospheric discharges.*

The use of a particular tone gives the sender a certain individuality. Turning again to the three stations at the corners of a triangle, if may be supposed that station *A* gives a sound with a frequency of 500 per second, and *B* one with a frequency of 1,000 so that *C* can receive telegrams at the same time to both stations quite separately with only one antenna, a receiving apparatus, a detector, and only when the two senders are transmitting oscillations of nearly the same wave length need two operators be present, one of whom writes down the telegram with the higher sound and the other the one with the lower. By this means great simplicity in working and quite considerable freedom from disturbances are obtained. It is no longer necessary to tune the receivers for multiple telegraphy, for it often occurs with this arrangement that the sender for which the receiver is not tuned begins to work. To prevent this danger a suitable working rule has not yet been found. Electrical tuning by using a long wave scale can also be obtained, and by this method not only two but a great number of stations can work without disturbance from each other.

The system of singing sparks allows an acoustic tuning of the receiver to be obtained by the use of clear musical tones, while these, as already shown, depend on the selective capacity of the human hearing, so that certain parts—for instance, parts of a so-called sound intensifier—can be imposed on the frequency of the sounds received, and prevent senders of other sounds, impulses from ordinary spark stations, and especially atmospheric disturbances from interfering.

As to a receiver for this new system, all the well-known acoustic receivers can be used, and no "ticker" is necessary at the receiving end. In spite of this, a new receiver has been designed for all sizes of stations, which both in construction and in electrical arrangement does not differ considerably from the present type of receiver. A special receiver has also been designed which, as a result of a number of measurements, has been shown to be capable of receiving over a large scale of wave lengths, from 200 to 3,000 meters, with a very small loss from damping in the tuning arrangements. The operation of the rectifying detector, working on the principle of the contact detector, is very sensitive, being about 20 per cent more sensitive than the electrolytic type. It is also very constant, and is not disturbed either by atmospheric discharges or by "over-intensity" due to neighboring or strong senders. In connection with this receiver two boosting apparatus have been designed which employ the special advantages of the new form of musical sender.

Both these apparatus are of great practical importance. There is then the calling apparatus, which is employed instead of the telephone receiver on the standard receiver, and rings an electric bell whenever a singing sender works for over 10 seconds; but for atmospheric discharges and for discharges from the usual spark sender, as well as for Morse signals, it does not ring, though the calling arrangement operates up to the limit of hearing capacity. The second apparatus is a resonance relay, which makes it possible to intensify the weakest signals while still keeping them as clear musical tones, so that they can be received in the station. Such an increase is only possible by the use of a body oscillating with mechanical resonance, and the sound must be quite clear. By the use of a relay, atmospheric disturbances are practically cut out, as single discharges only slightly influence the resonance system. Several relays of different tones make it possible to differentiate between signals from different senders which are transmitting with equal wave lengths but different notes, and differentiations to be made without the help of the human ear, which becomes tired.

* See Elektrotechnische Zeitschrift, 1909, No. 10, page 222.

BUILDING BRICKS OF GLASS.

A NEW STRUCTURAL MATERIAL.

For some time past more or less attention has been given abroad to the question of making bricks of glass which could be used in a practical way for building purposes, and with a view to ascertaining the status of this industry the United States consular officers in Europe were instructed by the State Department to obtain such information as might be available bearing upon the subject indicated and the value of such bricks for the purpose named. According to these reports, which have recently been issued, the most successful artificial stone which has been made from glass is that turned out under the Garchey patents, the products being known as the Garchey stone. For common tiles old glass obtained from broken bottles, window panes, etc., is used, as uniformity of texture and color is not absolutely essential. For higher grades of product glass is first made from sand of suitable quality, carbonate of lime, sulphate of soda and potash, the proportion being about 5 of sand, 4 of lime, and 1 of alkali. After being cooled slightly the glass is granulated by being thrown into cold water, the granules are put into refractory molds and again heated to a temperature below complete fusion until they become plastic. The molds are then withdrawn from the furnace, placed under a hydraulic press and subjected to a pressure necessary to form the plastic material into the desired shapes. After being trimmed the molds are passed through the cooling process in ovens specially constructed for the purpose. It is stated that the inventor has discovered another process for making the stone from glass in one heating by which the cost is materially reduced.

The stone is made in a variety of forms for paving streets, sidewalks, and gutters, and for the uses for which porcelain and other tiles are employed, such, for example, as tiling the walls and floors of bathrooms, operating rooms in hospitals, waiting rooms, and staircases of railroad stations, etc. As the Garchey stone has the chemical and physical qualities of glass it is not readily attacked by chemical products, so that it can be used in factories and laboratories where acids and other chemicals are employed, and being impervious to moisture can be used in cellars and other places where there is much humidity. The stone is also molded in ornamental forms and can be made according to the drawings of architects and interior designers for decorative purposes in drawing rooms, offices, etc. According to Consul Thackara at Havre, the Garchey bricks are not used in that vicinity in the construction of buildings, owing principally to their cost in comparison with other materials. Plain, smooth, or fluted tiles 7¾ inches square or 13 inches square and about ¾ inch thick are used for tiling the sides of kitchens, dining rooms, corridors, bathrooms, etc., as well as for flagging sidewalks, stables, passages, etc. The cost is said to be 19 cents per square foot. Highly ornamental tile 19.7 inches long by 13 inches wide cost about 64 cents each. The bricks, squares, and tiles are made in various colors, such as white, green, pink, white and black, yellow, etc.

The Garchey artificial stone is said to have a capacity for resisting a pressure of 28,774 pounds per square inch, and after being immersed in refrigerating mixtures developing a temperature of 20 deg. below zero C., the stone resisted a crushing pressure of 28,845 pounds per square inch.

In Grenoble several buildings have already been provided with glass bricks, and they are beginning to find favor with the general public, so that their use is rapidly increasing with builders and contractors.

In Germany glass bricks for building purposes are being used with measurable success, and there are several concerns engaged in their manufacture. At the International Exposition of Fire Extinguishing and Fire Preventing Devices, held in Berlin, 1901, one of the concerns exhibited a small villa, the walls of which were built of glass bricks in several shades of dark green and blue, attracting much attention. Glass bricks are especially adapted to the construction of walls and buildings where light, cleanliness, and neatness of appearance are especially desired. In Berlin they are made in two sizes, both 2 inches thick, 2¾ inches wide, and 5 and 10 inches long, respectively. The short brick have half the length of the longer ones. The edges are made with flanges which fit into countersunk recesses, so that the bricks may be laid with very little cement into air-tight and very firm although thin walls. The cost is said to be 11 cents each for the large and 9 cents each for the small size, from which prices there is, however, a large discount for quantities exceeding 1,000.

In Dresden glass bricks are made for building purposes, these being of blown glass, and owing to their hollow closed form are excellent temperature and noise insulators and do not sweat or freeze. They are made in various sizes and shapes and average from 3½ to 16 cents each. They are cemented together with mortar made of 3 parts sand, 1 part Portland cement, and enough white lime to render the mixture easily workable. For ventilation of glass brick buildings a special ventilator is constructed, of which a number can be readily inserted in any desirable location, as they conform exactly to the shape of the bricks.

In Hamburg glass bricks are occasionally utilized for building purposes, and in place of windows they are used to admit light in walls which, according to the police building regulations, are required to be fireproof and windowless. In addition to admitting light to dark hallways, rooms, etc., they are said to possess the same strength as ordinary clay bricks. They are also utilized in walls in yards and in partitions in the interior of houses, salesrooms, offices, workshops, etc., as well as for the construction of verandas, hot houses, kiosks, bathrooms, hospitals, ice factories, butcher shops, railroad stations, breweries, stables, and in other places where cleanliness, light, and uniform temperatures are particularly desired. The bricks are also made with a wire coating for fireproof walls.

In some of the recently erected buildings in Milan, Italy, bricks made of glass have been adopted for ground and upper floors on account of the light obtained. They are also coming into use for partition work in some of the hospitals on account of the hygienic principles. In one of the leading banking institutions of the city of Turin the lobby office floor, which is about 36 x 58 feet, is entirely paved with glass bricks laid in iron frames for the purpose of admitting light into the basement, where are located numerous private boxes or vaults.

Plain glass building bricks, hollow and of octagonal shape, are used in the Netherlands to a limited extent. Their principal application is for light giving purposes in walls of machine shops and conservatories. The bricks are of a greenish color and transparent.—Carpentry and Building.

BAMBOO IN CALIFORNIA.

ALL of the known varieties of bamboo in the Orient consigned in one shipment of 140 tons, the largest single importation of the growth ever brought to America, recently arrived in San Francisco direct from the East. This importation, consisting of 750 boxes, has been shipped to Chico, Cal., ten cars being required to convey the consignment to its destination. These plants will be placed in the National Plant Introduction Gardens at Chico, for propagation, until next spring. The bamboo came generally from the big nursery at Yokohama, Japan, and was gathered by Explorer W. D. Hill, who came over with the shipment. The usual inspection and fumigation of the plants were made by Inspector Ehrhorn, horticultural inspector, assisted by Chief W. W. Tracey, of Chico, and Dr. Moulton, of San José.

The Department of Agriculture has already telegraphed orders to have three large greenhouses constructed at Chico. The Agricultural Department at Washington at first considered the plan of propagating the bamboo plants at the large garden belonging to Millionaire Tevis, located at Bakersfield, Cal., but later decided to do this work at Chico. Next spring a great number of the bamboo shoots and sprouts are to be shipped to various parts of Southern California, where they will be planted for permanent cultivation. By repeated and thorough experimenting, it has been determined that the bamboo will flourish as well in California as in Japan or China. The growth can be used for many commercial purposes, as well as for ornamentation and beautifying of parks, public grounds, etc.

Ink for Writing on Photographs.—Dissolve 10 parts iodide of potassium and 1 part each of iodine and gum arabic in 30 parts of distilled water. With this solution white writing is produced on dark photographs.

GIANT LEAVES.*

SOME MONSTROSITIES IN FOLIAGE.

BY S. LEONARD BASTIN.

THERE are few things which impress the student of plant life more than the amazing diversity exhibited in the designs of leaves. The foliage of vegetation varies in shape, from the simple types of the lower orders, up to the most elaborate forms in the highly specialized groups. The variation in size is no less a matter for astonishment. The tiniest leaves of all are so little that it is not easy to think of anything smaller; while ranging upward from these there is a scale composed of individuals ever increasing in bigness, leading us on to huge specimens which are the marvels of the vegetable kingdom. And yet the purpose of foliage all the world over is the same, in a general sense—to carry out the respiration of the plant. It may not be uninteresting to speculate upon the diversity in the forms of the larger leaves, and to inquire as to the benefits which the plants derive from the special designs in a few of the most striking instances.

There is no getting away from the fact that the plant with very large leaves is at a distinct disadvantage, and it is not quite easy to see by what process certain species have become possessed of these huge organs. One would have thought that the all-powerful natural selection would have tended to modify the size of foliage, had not the facts, as far as some plants are concerned at any rate, shown otherwise. Plants with large leaves are almost world wide in distribution if we except the Arctic regions and those desolate wastes of scorching sand which will support little vegetation at all unless it be of a succulent habit.

In the first place the plant with big leaves has one important difficulty to contend against—it cannot produce very many of these organs. Thus if any part of the foliage is damaged the plant is likely to suffer pretty badly, for in some instances injury to one leaf might actually involve a sixth of the whole tree. Again, although some of the examples under consideration grow very rapidly, in the majority of cases it may be said that it takes relatively a long time to develop a new leaf if it has to be a very big one; and while this replacing is going on the plant will be suffering the loss of an important part of its being. But perhaps a still greater drawback to the big leaf, from the point of view of the economy of the plant, is the risk which it will run from wind damage. This is really a very serious matter indeed, and, as will be pointed out later, one which some very ingenious contrivances have been called forth to deal with. Lastly, the evaporation of moisture, always an important question in the plant world, will be much greater from a broad expanse than from a much restricted area. In this connection it is also instructive to observe that most of the species with large leaves find their natural home where water is abundant; some of them being even semi-aquatic in habit, and one of the most amazing plants being wholly so.

One is continually brought face to face with the fact that there must be some law of compensation. An animal or a plant is lacking in one particular direction, but to make up for this more often than not it is favored in some other way. One can hardly find a better instance of this than in the banana (Musa), a species of which has leaves ten or twelve feet in length. These great organs are nothing like so tough as one would think they should be in consideration of their size, and as a consequence suffer very much harm in more ways than one. In the matter of wind damage there is no tropical tree which is more grievous a victim. Any visitor to a banana plantation knows that after a fairly fresh breeze the leaves of the trees are simply shredded into ribbons and the foliage otherwise torn and bruised. But to make up for this serious deficiency the banana is one of those plants gifted with the power of most remarkably rapid growth. It is said that these leaves will extend upward at the rate of ten inches or even more in a single night, and it will thus be seen that it does not take very long for the banana to make good any damage which it may have sustained. Indeed, the vigor evidenced in the Musa tribe is one of the most extraordinary things in the whole plant world, when it is remembered that throughout the whole of its existence the tree does not cease to bear flower and fruit.

THE GUNNERA IS A GIANT PIE PLANT WITH LONG STEMS AND AMPLE LEAVES.

One can well pardon the popular fancy which has dubbed the Gunnera a giant pie-plant. With its long stems and ample leaves, it looks very much like the humble species of our gardens, but on what a prodigious scale! A tall man standing by a well-grown example of Gunnera is quite belittled, and yet this tremendous growth is made in a few short months. Most of the Gunneras are semi-aquatic in habit, and all are indigenous to the American continent, and in many ways it must be admitted that their size and habit render them fit to rank with the wonders of the earth. But in addition to the fact that these plants grow quickly, an examination of their foliage will show that their leaves, big as they are, cannot come to much harm. The general texture of the great organs is tough, and the cells are so arranged that evaporation of moisture will not go on at undue rate.

THE BANANA LEAF IS ONE OF THE LARGEST GROWN IN NATURE.

THE MODERN CABBAGE LEAF AS DEVELOPED BY CULTIVATION.

GIANT LEAVES.

* From American Homes and Gardens. Published by Munn & Co.

Moreover, by a nice adjustment, unless the plant is almost growing with the roots in water, it will not develop leaves of the largest size. The stem bearing aloft the huge leaf is hard and fibrous, unusually strong for one which is not at all woody. In fact the whole appearance of the Gunnera gives an impression of robustness and strength which is not often present in species of its class. In passing, it may be mentioned that these plants are of easy culture, and should appeal to the gardener on account of the great effect which a few specimens will give.

Many of the Aroideæ are most interesting plants on account of the size of the foliage which they produce. Some of the members of a large genus (Anthurium), commonly grown under glass as foliage plants, develop very big leaves even under artificial conditions. A species known as A. brownii not infrequently produces leaves as much as four or even five feet in length. The leaves of these species are of substantial texture and peculiarly well protected against damage from wind. It is interesting to observe the manner in which every vein of the leaf branching out from the mid-rib, instead of terminating at the extreme border, turns round in a curve and loops up with the one beneath it. Thus a kind of selvedge is formed which practically encircles the whole of the leaf, the value of which to check anything in the way of tearing is at once apparent. Most of the Anthuriums produce leaves which are really of very great beauty, and not a few species flower in a very attractive fashion, and on this account these tropical plants are in great requisition for the warm house.

Another interesting plant belonging to the Aroideæ is Monstera deliciosa, not uncommonly seen in large conservatories. The species produce very big leaves, thick and leathery in constitution, but still their very clumsiness would render them exceedingly liable to be injured. Instead of the border, which was so striking a feature in the Anthuriums, it is seen that the edge of the leaf is split up so that it forms a kind of a fringe; indeed one may say that it is torn already and will therefore not be likely to suffer much more hurt. The strange fillets in the interior part of the leaf will catch the eye at once, and it may not be out of place to inquire for a moment what is the meaning of this rather unusual feature. Under natural conditions the plant rambles up tall trees, and as there is a good deal of likelihood that the large leaves would obscure the light from each other, the holes in the organs serve a very useful purpose. They act as kinds of windows to the leaf which happens to be

THE MONSTERA DELICIOSA HAS VAST LEAVES STRANGELY HOLED AND BROKEN ON THE MARGINS.

THE ELEPHANT'S EAR OF SOUTH AFRICA PRODUCES ONLY ONE QUAINT LEAF.

ANTHURIUM LEAVES OF IMMENSE SIZE.

THE SINGLE LEAF OF THE SOUTH AFRICAN ELEPHANT'S EAR IS BEAUTIFULLY CURVED AND RIBBED.

GIANT LEAVES.

underneath, letting through the light and possibly the air which otherwise would be excluded.

Many plants related to the Arums produce large leaves. A Central American species known as Dracontinum gigas has been known to develop leaves which were no less than fourteen feet long. It is said that the whole plant is a most remarkable spectacle from the fact that the stem of this colossal leaf is beautifully mottled with purple and yellow, and has been compared "to a huge snake standing erect at the bidding of an Eastern charmer." But even here we do not reach the limit of what is possible in the way of giant foliage. Some of the achievements of the Sago palms in this direction throw everything else into the shade. Not so long ago one which, it may be observed, was in captivity, startled its owner by sending out a leaf which was estimated to be more than forty feet in measurement. As a matter of fact it is likely that this particular specimen would have been even longer than this had it been possible to allow it a freer growth than it could get under glass. Of course, in the open under very favorable conditions even this would be exceeded, though, as it may be imagined, the chances that such a great leaf would come to grief are very great.

As a general rule the water plants can not be said to be the possessors of very large leaves, but to this there is one very striking exception. Most people are now more or less familiar with the giant water lily (Victoria regia), specimens of which are not uncommonly to be seen in botanical gardens. Perhaps few are aware that this plant is an annual, the whole of its enormous growth being made in a few months. On account of the fact that the edge of the leaf of this water lily is turned up, its supporting power is very considerable. Very fine examples have been known to bear a man sitting on a chair, although it is only fair to say that the average leaf would not support such a weight.

In reviewing the question of big leaves it would be out of place not to refer to what man has done to increase the size of the foliage of plants for his own ends. This is well instanced in the case of the cabbage, a plant for whose ancestry we must look to a most insignificant species with small leaves. It is perhaps one of the greatest triumphs of the horticultural world that out of this useless plant (Brassica oleracea) has been created such a vast number of varieties of such great value to the whole race of mankind. The cabbage only produces its large leaves because it has been made to do so, and it will soon revert to something like its natural state if left unsurrounded by all the stimuli of artificial culture for any time.

THE FORM AND DIMENSIONS OF THE SUN.*

POSSIBLE CHANGES.

BY PROF. F. R. MOULTON, UNIVERSITY OF CHICAGO.

THE shape of the sun and the possibility of changes in its dimensions have been matters of keen interest to astronomers for about a century. Among those who have contributed to the discussion of these questions we may mention Von Lindenau (1809), Bianchi (1831), Secchi (1871), Auwers (1873 and 1895), Newcomb and Holden (1874), Ambronn (1905), and Poor (1908). In the last of Poor's papers there are full references and complete abstracts of all the most important discussions of the subject. It is sufficient to state here that up to Auwers's work in 1885 the observations were obtained with meridian instruments, that the later observations of Auwers and those of Ambronn were made with the heliometer, and that Poor's work, aside from a rediscussion of the heliometer measures of Auwers and Ambronn, was based upon twenty-two Rutherford plates taken in the years 1870-72, nine Northfield plates taken in 1893-94, and six Yerkes Observatory plates taken in 1907. In using these photographic plates, Poor limited his discussion to the question of the difference in the equatorial and polar diameters.

The results obtained in the various investigations have been most discordant. Von Lindenau reached the conclusion that there are periodic variations in the sun's diameter; from the same observation Auwers came to the opposite conclusion; Secchi found the diameter varying inversely with the number of sun-spots; Auwers, from the same data, found no variations; Newcomb and Holden reached the result that there is no long-term variation; in his first discussion of the heliometer observations Auwers found that the diameter varies directly as the number of sun-spots, and in a second discussion that the apparent variation was due to varying personal equations; and Ambronn was convinced that during the interval of thirteen years covered by his observations there was no periodic or secular change in the diameter of the sun exceeding 0.1 sec.

The conclusions respecting the shape of the sun were equally varied, the polar diameter being found a little greater than the equatorial about as often as the opposite. Poor infers from all the evidence that "the exact shape of the sun is not known with certainty"; and that the difference in the polar and equatorial radii is probably not more than 0.25 sec. He states that the heliometer observations show a fluctuation in the size of the sun of probably not over 0.10 sec. Ambronn thinks there is no observational evidence of changes in its dimensions.

Under the hypothesis that the sun is rotating without oscillations, we find that it must be nearly an oblate spheroid, and that the difference between its equatorial and polar diameters must be less than 0.07 sec. as seen from the earth.

It is well known that such a fluid mass as the sun may undergo oscillations whose amplitude and character depend upon the nature of the disturbances producing them, and whose periods depend upon the character of the oscillations, and upon its mass, density, and elasticity. Whatever the nature of the oscillations, the question of the surface of the body can be represented as the sum of a converging series of spherical harmonics whose coefficients are periodic functions of the time. For simplicity, it is assumed that the mass always has an axis of symmetry so that its surface can be defined by zonal harmonics. It is also assumed that at every instant the mass is homogeneous throughout. With these restrictions, the surface, volume, moment of inertia, and self-potential of this mass of general variable form are computed.

The first practical question is whether a dilatational oscillation will not change the rate of rotation so that the change of period of rotation can be observed even though the change in diameter is beyond direct observation. The answer is in the negative, for a shrinkage of diameter of 1.0 sec., as seen from the earth, would decrease the period of rotation by only 38 minutes.

The second question is regarding the change in temperature produced by a dilatational oscillation. An oscillation of this type such that the whole change in the sun's diameter as seen from the earth is only 0.1 sec. is, assuming the specific heat of the sun as unity, 1,400 deg. C.

It is found then, assuming Stefan's law of radiation, and that the absolute temperature of the sun at mean radius is 6,000 deg., that a variation of temperature 700 deg. each side of this mean would result in a variation from 61 per cent to 156 per cent of that at mean radius. That is, the radiation at maximum would be 2.56 times that at minimum, or a variation of little more than a star magnitude. Consequently, if the sun were oscillating in this way the changes in its rate of radiation would be observed long before those in its diameter. An extreme oscillation of 0.01 sec. in the sun's diameter as seen from the earth would account for the variations of 10 per cent in the solar radiation observed by Langley and Abbot.

The question of oscillations defined by zonal harmonics of the second order is considered. The potential energy is a minimum when the coefficient of this harmonic passes through zero, that is, at the instant when the body is spherical; and has two equal maxima when the body is most prolate and most oblate. But when the potential energy is a minimum the kinetic energy of the oscillation is a maximum. Consequently the range of variation of temperature cannot be exactly computed without knowing the motion of each element of mass at the critical times. Since this is an unsolved problem, a rough computation was made to determine an upper limit to the kinetic energy at the time the mass is spherical, and therefore a lower limit to the range of variation of temperature. It was found that a variation of this type such that the equatorial diameter changes by 1/70 its value would cause a variation of temperature of 1,600 deg. C. At its greatest oblateness it would be relatively flattened one-fourth as much as Saturn is now. The radiation at maximum would be 2.6 times that at minimum, or more than a star magnitude greater. An oscillation of this type producing a change of 10 per cent in the solar radiation would cause a variation in the sun's equatorial diameter, as seen from the earth, of 7.4 sec.

The period of these oscillations is of interest. Kelvin's formula shows that if the sun were a perfect incompressible fluid the period of the oscillations depending upon the harmonics of the second order would be 3 hours and 8 minutes. The period is independent of the mass and varies inversely as the square root of the density. The work of Lamb shows that if the mass had the viscosity of water the amplitude of the oscillation would be reduced to 37 per cent of its original value in 22×10^{10} years. The former of these two results is almost certainly of the right order of magnitude for the actual sun; the latter is probably much too great.

The results obtained by me suggest the idea that certain classes of variable stars may owe their variability, at least partially, to oscillations. Reference is made particularly to stars whose light changes continually, such as those of which δ Cephei is the type, and those of the β Lyræ type. The spectroscope proves that in the δ Cephei stars the light-variations are not eclipse phenomena, and in case of β Lyræ the phenomena are so complicated as to suggest that eclipses are not the sole cause of the variability. If oscillations of sufficient magnitude are admitted they would explain rather satisfactorily most of the phenomena of these classes of stars. For a star of the mass and density of the sun an oscillation defined by the second-order harmonic amounting to 1/50 of its radius would acount for all the light changes in these classes of stars. However, the periods of variability demand very low densities, yet greater than one-third of those required if we attempt to explain the light variations on the eclipse theory. For a period of 5 days the density is 10^{-3} on the water standard.

The question at once arises as to the cause of the possible oscillations. In the case of a binary system having an eccentric orbit, the periodically changing disturbance of one star by the other is an efficient cause. A single star would be set vibrating by a collision with another body even of planetary mass, and by passing near another star. The fact that the sun now has a remarkable equatorial acceleration, as well as an unexplained 11-year cycle, tends to make us open-minded regarding the much simpler oscillations treated in this paper.

* Astrophysical Journal.

THE SCHOOL ROOM DUST PROBLEM.

ONE of the most unpleasant things with which teachers in public schools have to contend is the method of sweeping and cleaning the school rooms. In most cases the rooms are dry swept, which means that the dust and dirt is made the vehicle for the distribution of many pathogenic germs. This dust evil is one of the greatest problems of sanitation left for public school authorities to solve. Much attention has been given, as it should be, to the proper heating and ventilating of our school buildings. The food and water supply have received much attention. It is seen that the plumbing is properly set and in many schools fire escapes have been provided. These things are all good, and it is well that they are being looked after with much care and intelligence. This dust problem, in many respects the most vital of them all, has received the least attention. Dry sweeping, instead of removing the dirt, divides it into finer particles which float in the air and are finally settled on everything in the room to be stirred up the next day by the pupils and taken into their lungs. The wonder is that we do not have more pupils infected with one form or another of tuberculosis.

The eradicating of the dust nuisance lies in the installation of a vacuum cleaning apparatus in every school, and for that matter, in every public building. In new buildings the extra cost would not be very much, as the exhaust pipes would be placed in walls during construction, all leading to the exhauster in the heating room. The extra expense would soon be met by the saving in cleaning materials and janitor service. The crayon dust nuisance may also be overcome by using vacuum blackboard erasers, which are the very latest things in school building equipment.

Mr. Robert L. Cooley, principal of the Sixteenth District School No. 1 of Milwaukee, Wis., has had installed in his building a vacuum cleaning apparatus, and his testimony is nothing but praise for its successful working in his school. He says the system has completely solved the dust nuisance with him.—School Science and Mathematics.

SIR GEORGE DARWIN ON "TIDES IN THE SOLID EARTH."

AT the Sedgwick Museum of Geology Sir George Darwin delivered a lecture on "Tides in the Solid Earth." The lecture was illustrated with lantern slides.

Sir George Darwin said that the existence of tides in the solid earth was first indicated by Lord Kelvin in 1867, and popular attention had recently been drawn to the subject by some remarkable observations recently made by Dr. Hecker at Potsdam. The first numerical estimate of the amount of the tidal oscillations of the solid earth was made by the lecturer in 1882, and formed a contribution to the second edition of Lord Kelvin's and Tait's "Natural Philosophy." The estimate was based on an indirect method, and resulted from observation of the tides of the ocean. Further indirect methods had been successfully applied at later times, with more complete data than were available twenty-five years ago. The result appeared to be that the earth yields to the tidal forces due to the sun and moon to about the same extent as if it were made of steel.

Dr. Hecker's more direct plan of attack was the same as that pursued by certain earlier observers, but he succeeded in obtaining far more trustworthy results in consequence of his great skill in matters involving delicate observation. The plan was equivalent to an observation of the amount by which a plumb-line was deflected from the true vertical by the attractions of the sun and moon. The deflections were, however, so minute, that it would be impossible to measure them by the observation of an actual plumb-line. An extremely sensitive form of instrument, called a horizontal pendulum, had been devised whereby the microscopic deflections of the apparent direction of gravity might be measured. In order to avoid the disturbing effects of changes of temperature at the earth's surface, Dr. Hecker erected his instruments in a chamber excavated in the side of a well at 80 feet below the earth's surface. He there obtained continuous photographic records of the apparent deflections of the direction of gravity during two years, and the results of those observations were explained in the lecture. The principle whereby these observations afford a measure of the amount of tidal yielding of the solid earth is as follows: It is possible to calculate the curve which would be described by a plumb-bob on the hypothesis that the solid earth is absolutely unyielding; further, if the solid earth yielded as freely as water, the plumb-bob would appear to be at rest; next, if the earth yielded, but not as freely as does water, the plumb-bob would seem to move, but not so much as was calculated. Hence a comparison between the curve actually described by the plumb-bob and the calculated curve affords a measure of the amount of yielding of the solid earth. Dr. Hecker's results confirmed the earlier estimates of the amount of the tidal movement of the solid earth very closely, and they possessed a much higher degree of accuracy.

Sir George thought we might now feel confident that the earth yielded to the tidal forces to the same degree as would a steel globe. He pointed out the amazing accuracy of Dr. Hecker's observations, and drew attention to some collateral points, among which may be mentioned the flexure of coast-lines, due to the varying pressure of oceanic tides, and the effects of high and low barometric pressure in bending the earth's surface. It was impossible, he said, to give an accurate measurement of the amount of the vertical motion of the earth's surface; but it was probable that at spring tides in this latitude the surface of the solid earth moved up and down through about six inches.—English Mechanic and World of Science.

THE CHARGE AND NATURE OF THE ALPHA PARTICLE.

IN recent experiments by Rutherford and Geiger, they arrived at the following conclusion: The atomic weight of an α particle is 3.84. The atomic weight of the helium atom is 3.96. Taking into account probable experimental errors, they conclude that the α particle, after it has lost its positive charge, is a helium atom.

There is direct evidence in the case of radium that each of the α ray changes is accompanied by the expulsion of one α particle from each atom. Consequently since the atomic weight of radium is 226 the atomic weight of the emanation is 222, and of radium A 218.

One atom of radium, in breaking up, emits one α particle and gives rise to one atom of emanation of atomic mass 222. Since 3.4×10^{10} α particles are expelled per second per gramme of radium, the number of atoms of emanation produced per second is the same. There are 2.27×10^{10} molecules in 1 cubic centimeter of any gas at standard pressure and temperature. The volume of the emanation produced per second per gramme is 1.25×10^{-5} cubic centimeter. The maximum volume of the emanation from 1 gramme of radium is therefore 0.585 cubic millimeter. The volume of helium produced per gramme is 5.0×10^{-5} cubic centimeter per second, which is equal to 0.43 cubic millimeter per day.

The life of radium works out to be 1,760 years. Heating effect per gramme of radium, 113 gramme-calories per hour. Number of atoms of radium breaking up per second, 3.4×10^{10}.

Hon. J. R. Strutt, as the result of studies on various rocks, arrives at these conclusions:

1. Phosphatic nodules and phosphatized bones of all geological ages possess marked radio-activity many times higher than that of rocks. This activity is due to products of the uranium series.
2. Helium has been detected in these materials.
3. The ratio of helium to uranium oxide has been measured. This ratio does not strictly follow the order of superposition of the strata, but high ratios are not met with in the younger deposits, whereas they are common in the older ones.—Abstracted from Proceedings of the Royal Society.

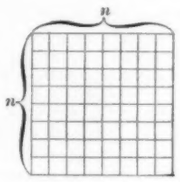
Correspondence.

CURIOUS FACTS ABOUT NUMBERS.

To the Editor of the SCIENTIFIC AMERICAN:

I have been reading with interest the contributions of your readers on curious facts about numbers, which have from time to time been published in your valuable paper, and sincerely hope that this will continue to be a feature of the SCIENTIFIC AMERICAN. Although the following may not strictly be classed among curiosities of numbers, I believe that it will prove of interest to your readers.

Many magazines and "puzzle books" present a figure like the following, in which it is required to count the total number of squares, such as the small squares, those made up of four small squares, the large square, etc.:



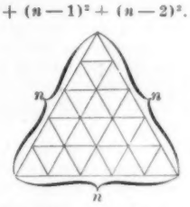
The usual method of solving the puzzle has been to count the squares, taking up each possible combination. This operation has, no doubt, required several hours of work, in order to make certain that no squares have been missed. It is my purpose to show a much simpler and quicker method.

Thus, in the above figure, we have: 64 small squares, or 8^2; 49 squares consisting of 4 small squares, or 7^2; 36 consisting of 9 squares each, or 6^2; 25 consisting of 16 squares each, or 5^2; 16 consisting of 25 squares each, or 4^2; 9 consisting of 36 squares each, or 3^2; 4 of 49 squares, or 2^2; and 1 of 64 squares. Then the total number of squares is:

$64 + 49 + 36 + 25 + 16 + 9 + 4 + 1 = 204$ squares.

Thus we obtain the formula for the *total number of squares in a large square* (s_1) *having n squares on each side:*

$$s_1 = n^2 + (n-1)^2 + (n-2)^2 \ldots\ldots 0.$$



Thus, for a square having 6 on each side, there are, all told: $6^2 + 5^2 + 4^2 + 3^2 + 2^2 + 1^2 = 36 + 25 + 16 + 9 + 4 + 1 = 91$ squares, which will be found correct by actual count.

In a like manner we may obtain the formula for the total number of triangles in a large triangle (s_2) having n triangles on each side:

$$s_2 = n^2 + (n-1)^2 + (n-2)^2 \ldots\ldots 0.$$

Thus, the above triangle, with $n = 5$, has, all told: $5^2 + 4^2 + 3^2 + 2^2 + 1^2 = 25 + 16 + 9 + 4 + 1 = 55$ triangles.

To obtain the total number of cubes in a large cube or the total number of pyramids in a large one, it is necessary to *cube* each number, instead of squaring it.

The formulæ are:

$$s_3 \text{ or } s_4 = n^3 + (n-1)^3 + (n-2)^3 \ldots\ldots 0.$$

Thus, in a cube, having each face bounded by 4 squares, the total number of cubes is:

$4^3 + 3^3 + 2^3 + 1^3 = 64 + 27 + 8 + 1 = 100$ cubes, which will be found correct by actual count.

New York. W. NETTER.

LANTERN PROJECTION DISTANCES.

To the Editor of the SCIENTIFIC AMERICAN:

The usual published tables of size of disk for a given distance from screen with a three-inch slide for different focus lenses in projection, are perhaps near enough for all ordinary exhibition purposes, but not sufficiently so for accurate projection calculations. The tables give a constant ratio between disk and distance, same as a pinhole lens would give, whereas the conjugate focus of an objective naturally increases the disk greater in proportion than the distance calls for, amounting to nearly 18 inches for a 21-foot disk with a half-size objective, as per the table herewith, from actual experiments by the writer.

TABLE OF LANTERN PROJECTION DISTANCES.

Screen to Objective Diaphragm.	Least Conjugate Focus.	Diameter of Disk from 3-Inch Slide.	Same from 3¼ Inch Slide	Times Enlargement.	Ratio, 3-Inch Slide to Conjugate Focus.	Disk of Published Tables 3-Inch Slide.
Ft.	Ins.	Ft. Ins.	Ft. Ins.			
10	10.00	3 0	2 10⅝	12	3.333	3.00
20	9.60	6 3	6 0	25	3.220	6.00
30	9.47	9 6	9 1⅛	38	3.158	9.00
40	9.41	12 9	12 3	51	3.137	12.00
50	9.37	16 0	15 4	64	3.125	15.00
60	9.35	19 3	18 5⅛	77	3.117	18.00
70	9.33	22 6	21 7	90	3.110	21.00

The 73-foot floor of the Portage, Wis., armory was selected, and experiments made February 15th, 1907, through the courtesy of Company F, Third Regiment, some of the members of which kindly assisted with the measurements.

The alternating 10-ampere arc lamp was used in the lantern. The objective was half size, 9¼-inch equivalent solar focus, according to the one-fourth equal-image distance formulæ. The slide used was a hymn, words and music, full field, having a 3-inch exact mat, focusing sharp at half way from center to edge.

As a slide with a 3-inch mat opening is a rarity, and 2⅞-inch horizontal being the almost universal width, a column is also given for disks from this width, which ranges tolerably close enough to the usual tables for ordinary purposes. The ratio of slide to focus should be the same as disk to distance, and is, closely.

Portage, Wis. H. W. GRIGGS.

MALTED COFFEE.

THE proper drying of coffee for export presents many difficulties and often involves considerable loss, especially in regions where the crop is necessarily harvested in the rainy season. These difficulties are easily surmounted by wealthy planters, provided with improved machinery, but artificial drying is beyond the means of most of the small planters, who are entirely dependent on the sun's rays. Before the sun consents to shine the piled-up coffee becomes wet, heats, ferments, and, if sufficient space and hands for frequent turning over with shovels is lacking, or if the wet weather is long continued, putrefaction commences and the entire crop may be ruined. On the other hand, if the rain ceases and the sun shines for a few days in succession, the beans sprout under the combined influences of heat and moisture. For a long period sprouted coffee was regarded as unfit for use.

In view of this state of affairs, the agricultural experiment station of Porto Rico recently undertook to determine the length of time during which coffee can remain wet without injury and also the effect of germination upon the quality of the coffee. Fermented coffee was washed, piled on a cement floor and turned over daily. Within a month germination commenced. The coffee was then spread over a larger surface in a uniform layer about one foot deep. The daily turnings were continued, but the coffee was sprinkled with water before each turning, and the sprouted beans were removed as fast as they appeared. Within another month all the beans had sprouted but no putrefaction or bad odor was developed in the whole course of the experiment.

The sprouted coffee was dried and shelled in the usual way. Specimens were submitted to several experts who unanimously declared it superior to ordinary coffee, as it had a more delicate flavor and had lost much of the bitterness characteristic of Porto Rico coffee. The malting or sprouting of coffee was, therefore, declared to be doubly advantageous because it diminishes and perhaps eliminates loss and also appreciably improves the quality of the product.

This practical conclusion is well established as a commercial fact, but a scientific study of the conditions which give the best result still remains to be made. The temperature and the degree of humidity should have been noted daily and at the same time average specimens should have been taken and analyzed, for the purpose of studying the successive stages of the process of transformation of which only the final result is now known.—Cosmos.

In March of this year the little village of Gassin, perched on a mountain ridge in the south of France, was visited by a thunderstorm, and the belfry of the church was struck by lightning. The electric discharge followed the steel bell rope and set the bell ringing. The doors of a cabinet containing candelabra were torn off and the candles in the cabinet were lighted. Thence continuing its course the lightning tore up the floor of the sacristy and neatly rolled up the carpet.

PHOTOGRAPHING WITHOUT LIGHT.

THE ACTINIC ACTIVITY OF RESIN AND ALLIED BODIES ON A SENSITIZED PLATE.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

INTERESTING researches concerning the action of bodies on a photographic plate in the dark have been carried out by Dr. William J. Russell, F.R.S., with metals, woods, juices of plants, etc., most of them showing the curious property of acting on a sensitized plate in the absence of light. His latest experiments have been effected with resin and allied bodies such as amber, peat, coal, lignite, etc., and the results have been given in a paper before the Royal Society. Through the courtesy of Dr. Russell we are enabled to reproduce herewith some of the most striking photographs.

The means by which these photographs can be secured is very simple. Lay them upon a photographic plate in the dark, and develop the latter in the usual manner. The experiments call for no particular sensitized plates, so long as they are of a good standard make and fairly rapid. At ordinary temperatures the action is very slow, for instance, with resin the contact should last about three days to secure a fairly good picture, but Dr. Russell found various methods of expediting the exposure. If amber resin is heated and contact made at from 86 to 104 deg. F., from three to four hours' exposure will secure a definite picture; in fact, at the latter heat ordinary resin will give as much action as three days at normal temperature.

It is not essential that the resin and sensitized plate be brought directly into contact. If the plate is held some distance above the resin, the action still takes place and will pass through a considerable space.

The presence of oxygen brings about this actinic tact with a plate at a temperature of 131.5 deg. F. for five hours, a dark picture was secured.

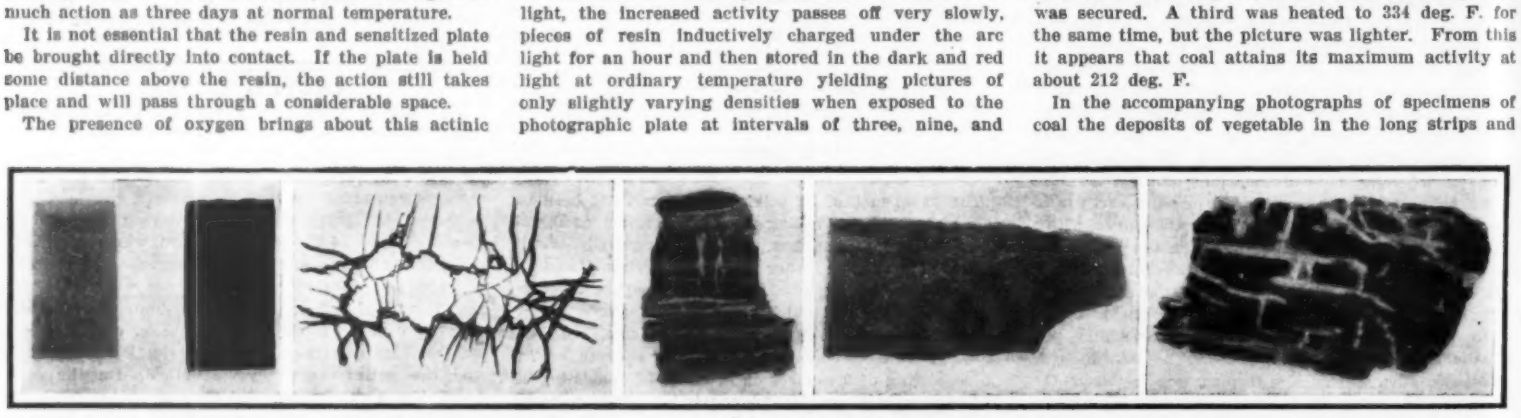
Activity can be decreased or destroyed by various treatments. Similarly, it can be strengthened temporarily by exposure to sun or electric arc light before being photographed. This is shown by the illustration which gives the photograph of pieces of resin exposed and unexposed to the arc light respectively, and afterward brought into proximity with the sensitive plate. The former was exposed to the arc light for half an hour, and gave a dense black picture, while the unstimulated piece yielded only a faint record. This induction of light, however, can be completely nullified under the action of carbon dioxide, or the intervention of a glass or mica screen. Sunlight brings about a similar stimulation, and a short interval elapses after the application of the light before induction commences. However, the increase in activity takes place very rapidly, and under the arc light becomes charged to its maximum in about five minutes.

Spectrum analysis shows that blue rays are the most active in this actinic stimulation, while the red are negative, and green produces a slight increase. If stimulated resin be kept in the dark or under a red light, the increased activity passes off very slowly, pieces of resin inductively charged under the arc light for an hour and then stored in the dark and red light at ordinary temperature yielding pictures of only slightly varying densities when exposed to the photographic plate at intervals of three, nine, and

or dissolved in alcohol, pronounced activity was observable. Ordinary coals if brought into contact with the sensitive plate and heated to about 122 deg. F. were found very active, giving well-defined pictures, so sharp indeed that enlargement five or six times rather enhanced their appearance. Most English coals were found to be capable of acting on the sensitized film in varying degrees. The specimens were obtained by sawing a piece from the rough block, and then rubbing down the face with coarse and finally fine sandpaper till it was flat and true. The smoothed surface was then laid down on the photographic plate at about 122 deg. F. and exposed for 18 hours; but in some cases this was prolonged to 48 hours in order to obtain definite results. It is essential, however, that the coal be perfectly dry, an end attained by heat drying or holding it over sulphuric acid.

Sometimes powdered coal is the more convenient to use, the *modus operandi* being the same as with resin. Or the substance may be slightly heated, and this if carried on within certain limits will give improved results. For instance, one sample of powdered Seaham coal was exposed straightway, and a fairly good picture was procured. The second was heated for 24 hours at 212 deg. F., and a much darker picture was secured. A third was heated to 334 deg. F. for the same time, but the picture was lighter. From this it appears that coal attains its maximum activity at about 212 deg. F.

In the accompanying photographs of specimens of coal the deposits of vegetable in the long strips and



Showing stimulative effect produced by exposing resin to a bright light.

Cracks in resin pictorially reproduced by actinic activity of the substance.

Bituminous coal showing layers and patches of vegetable with presence of soft powder, very active at top.

Cannel coal. The picture is not so dark or so well defined as that produced by other coals.

Anthracite coal, showing even distribution of vegetable matter and distinctive white cracks.

activity. This was demonstrated by placing two slabs of resin separately in two desiccators. The first was filled with dry air, and the other with carbon dioxide. Sensitized plates were placed one millimeter (0.039 inch) beneath the resin slabs and kept there for 18 hours, the temperature being 104 deg. F. The plate beneath the resin in the first desiccator showed considerable action, while nothing had developed in the other. The action will not pass through the thinnest sheet of glass, mica, tinfoil, or aluminium, the phenomenon being completely arrested by the insertion of a piece of glass 0.02 inch thick. Another feature is the form of the shadow produced. If a glass screen be placed between the resin and the plate, the impression on the film is not bounded by straight lines corresponding to the dimensions of the screen; but the action, like vapor, creeps over the edges of the glass on all sides until at last the waves meet in the center of the photographic plate. Activity is not dependent upon the thickness of the resin, for a thin plate will act quite as energetically as a thick one, pictures of the same density being secured from slabs 0.017 and 0.29 inch thick.

The best method of securing a resin slab is to melt the substance and then pour it on a bright metal plate, the surface which comes into contact with the metal being afterward freed from air bubbles by passing over it a gas flame.

If resin be maintained at a temperature of 122 deg. F. for 20 or 30 hours, its activity is only slightly diminished, but if at 316 deg. F. for 4 hours, the action is perceptibly diminished. One accompanying illustration shows an experiment with a piece cracked in all directions by a weight. When photographed for a short time, a dark record of the branching cracks was obtained. Again, the existent activity of resin can be transferred to a non-active body, which thereby becomes as active as the original. A glass vessel was nearly filled with crushed resin, and above this at a distance of 5 millimeters (0.0197 inch) a piece of inactive Bristol board was placed, and left for a week. When subsequently this board was brought into contact with a plate at a temperature of 131.5 deg. F. for five hours, a dark picture was secured.

eighteen days in comparison with one exposed immediately after presentation to the electric light. Again, although bodies such as glass are opaque to the activity, porous substances offer no obstruction. Ordinary paper enables interesting pictures to be obtained, showing the watermark and structure of the material. Paper glazed or highly dressed resists the passage of the action.

The principal constituent of resin is said to be the abietic acid, which acts remarkably upon a photographic plate. It is obtained from the resin by dissolving the latter in alcohol and then passing hydrochloric gas through the solution, thereby isolating the acid in a crystalline form. The results are very similar to those obtainable with ordinary resin, and it has the same light-inductive qualities. By dissolving the acid in alcohol and pouring the liquid over a plate, afterward allowing the spirit to evaporate, excellent films may be secured.

Dr. Russell made some experiments to ascertain the actinic properties of amber. It was found ordinarily to exercise no effect upon the photographic plate, even if the contact were continued for 18 hours at a temperature of 104 to 122 deg. F., thus being quite different from resin. The experiments were continued with amber pebble from all parts of the world, and in each instance genuine amber was found to produce a negative result.

Although pebble amber itself is non-active, signs of latent activity in the substance can be proved by powdering and then placing it in a glass dish with a photographic plate above. Upon development a dark picture will be found. Again, although amber is practically insoluble in alcohol, yet when immersed therein a small quantity of some active substance becomes separated therefrom. When amber is exposed to strong light, its activity like that of resin is increased, but this stimulating property of light was found to be a very variable quantity, and not nearly so marked as with resin.

Bovey, Tracey, and Victorian "brown coal" were found to be slightly active. With jet when powdered

patches are plainly discernible, and it is evident that this substance is well diffused throughout the mass. They tend to show clearly the differences in various grades of coal; the anthracites can be plainly distinguished from the bituminous and cannels. In the anthracites the pictures are fainter, the structure is more complicated, and the active substances more evenly distributed throughout the mass, while cracks always appear and are always white. Cannel coals yield somewhat similar pictures, but there is less detail and they are not so dark or defined. In bituminous coals the soft powder is exceptionally active, and its presence can be readily detected by a distinct diffusion on the plate. By permitting coal to record its own picture upon the sensitized film in this manner, it is possible that valuable assistance may be extended to the geologist in his task of explaining the formation of coal; while within certain limits it appears to offer an excellent means of identifying various coals, each of which apparently possesses its own photographic individuality.

Dr. Russell claims that this phenomenon is the emission of a vapor rather than any form of radio-activity. This is substantiated by the action of resin under a piece of glass, where instead of defining the edges of the glass, it creeps beneath it over the photographic plate; that it will not pass through such substances as glass, mica, tinfoil, and aluminium, and does not affect an electrical field, and that the action can pass along a bent tube or be swept out of a straight horizontal tube by a slow current of air. Moreover, no action occurs where there is an absence of oxygen, while on the other hand inactive liquids such as alcohol, petroleum spirit, and other solvents impair the activity.

The action which strong light exercises in increasing the activity of many bodies is considered highly important, since many bodies which under ordinary conditions are either inactive or only slightly so, become very energetic after exposure to sunlight or other bright light, or when simply exposed to the blue rays.

METALLOGRAPHY: A NEW SCIENCE.*

THE APPLICATION OF THE MICROSCOPE TO THE STUDY OF METALS.

BY WALTER ROSENHAIN

THE uses of the microscope, in the study of metals, are of several distinct kinds. I am not so much referring to the distinction between the scientific and the practical aspects of the subject, as to that between the different branches of the subject, each and all of which, however scientific they may appear, have considerable importance from the practical point of view also. A complete knowledge of metals—and particularly of those metals which are employed for practical purposes—includes, in the first place, a complete knowledge of their chemical constitution, a knowledge not only of the chemical elements present, and their quantitative proportions, but also of the manner in which they are combined, and the relative arrangement of the various constituents; in obtaining this knowledge the microscope has proved an invaluable ally to the study of metals and alloys by the aid of the pyrometer and by other methods of investigation. Further, we must know the defects or "diseases" to which metals may be subject, and in obtaining a knowledge of what might be termed the "structural pathology" of these defects or diseases the microscope is essential, while it provides us with an almost unfailing means of diagnosing these diseases on the occasions when "post-mortem" examination of a broken or damaged object is required. Finally, we require to know something of the physical internal structure of our metals—of the intimate nature of their structure—of the growth and mode of formation of crystals and of the manner in which these crystals undergo the varied changes of shape which are so constantly applied in metals; and here again the microscope has thrown light into places that were formerly dark, and has furnished a clear explanation of the phenomena of plastic deformation and of fracture under fatigue or shock—explanations which, when more fully realized by metallurgists and engineers, will lead to a better understanding and a more rational control of the every-day phenomena of metals.

In studying the chemical constitution of alloys the microscope enables us to determine with considerable accuracy to which of a small number of possible categories any specimen of alloy may belong. For instance, the class of pure metals and pure intermetallic compounds always possesses a very definite and characteristic structure—they are simply aggregates of minute crystals, all of which are of the same kind, merely differing from one another in respect of the orientation of their respective crystalline planes. These crystalline planes are not, as a rule, obvious when a section of metal is observed by reflected light, since the boundaries of the crystals are not of geometrical form. The external geometrical form of a crystal is only developed when the crystal is formed either in a free liquid or in a very plastic solid; in a solidifying metal, however, the growing crystals interfere with one another, and their final boundaries are simply the surfaces upon which they met when growing outward from their respective centers of crystallization. In section, such a structure appears as a network of irregular polygons, but when suitably etched, the crystalline orientation of each of these polygonal areas becomes manifest by a peculiar appearance specially evident when the section is viewed under oblique light. So characteristic is this appearance that it has received the name of "oriented luster," and it may be readily observed on a large scale by "etching" a smooth piece of tin plate in strong hydrochloric acid. A piece of cast lead, etched in dilute nitric acid for some time, also shows this feature on a relatively enormous scale; in such a metal as iron, on the other hand, the crystals are usually so minute that they can only be seen clearly under a magnification of 200 diameters.

A second class of metallic bodies frequently possesses a micro-structure very similar to that of pure metals or pure compounds; these are the bodies known as "solid solutions." These are alloys in which the state of mutual solution of the two component metals which exists in the liquid state persists unchanged in the solid, crystalline state. The term simply implies a solution which—unlike a great many solutions—has solidified without undergoing any separation of its components. Many of our most useful alloys, such as the best varieties of brass and bronze, are examples of this class of alloy. As their micro-structure is so very similar to that of a pure metal, they cannot be readily distinguished from pure metals except by the aid of chemical analysis, but in some cases their structure shows traces of their more complex nature. Although it is typical of these bodies that in their final solid condition, if sufficiently slowly cooled, the state of intimate mixture of their component metals is the same as it was in the liquid solution from which they were formed, there is none the less a certain amount of separation which takes place temporarily during the freezing process, and if this has been carried on rather rapidly, complete equilibrium may not be attained, and the resulting structure, although consisting of an aggregate of "polygonal" crystals, may yet show traces of layers of varying composition within each of these crystals—and this is a feature which can usually be seen in any rapidly-cooled solid solution.

A considerable number of solid solutions of this kind, which are formed and remain stable at high temperatures, become unstable at lower temperatures and tend to deposit crystals of a new constituent, much as hot saturated salt solutions often tend to deposit crystals of the salt during cooling; in some cases this is a gradual process, but in many cases the change takes place at a definite temperature, which is then known as a critical or transformation temperature. One of the best-known of these changes is that which takes place in ordinary carbon steel when the carbon passes out of the solid solution in which it remains down to 680 deg. C. and separates in the form of plates or crystals of carbide of iron. It is the suppression of this change by sudden cooling or quenching which results in the hardening of steel. As a rule, however, the quenching process is not sufficient to suppress entirely any of these changes—the most rapid mode of cooling still allows several seconds to elapse between the commencement of cooling and the time when the metal is so cold that its molecules can no longer rearrange themselves with any degree of rapidity. For practical purposes this slight amount of change in the case of steel is rather an advantage than otherwise, since in the subsequent "tempering" of steel by gradual reheating, this very change is partially brought about in order to restore some of its toughness to the steel. For experimental purposes, however, where the object of quenching is to stereotype, as nearly as possible, the structure existing at any given high temperature in order to obtain an insight into the various changes and rearrangements which occur during slower cooling, it is essential that the quenching process should be as rapid and vigorous as possible, and that it should take place at a definitely known temperature, while the preliminary heating of the specimen of metal should be carried out in such a way as to avoid oxidation or other chemical action. For this purpose I have devised a special apparatus in which the specimen of metal—in the form of a small rod or disk—is heated *in vacuo* in a tube of fused quartz which passes through a small electric resistance furnace. The exhausted tube communicates by means of a large tap with a vessel containing water or other quenching liquid, and when the desired temperature has been reached—as indicated by means of a thermo-couple placed in contact with the specimen—the heating current may be switched off and the large tap opened. Under the pressure of the atmosphere the water rushes into the heated silica tube and washes the specimen down into a large receiving flask at the other end. The silica tube is not injured by this treatment, and there is no risk of explosion when the apparatus is correctly proportioned. [The apparatus was shown in action.]

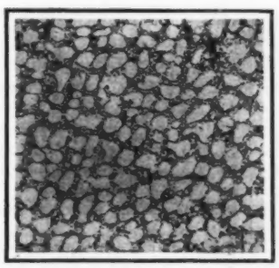


FIG. 1.

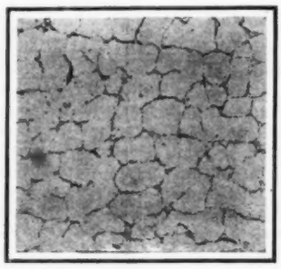


FIG. 2.

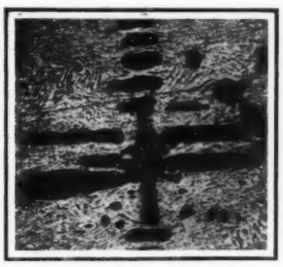


FIG. 3.

Fig. 1.—Alloy of tin with 10 per cent of lead. The presence of the dark eutectic constituent is seen. Fig. 2.—Alloy of tin with 20 per cent of lead. The eutectic constituent is present in large proportion. Fig. 3.—Alloy of tin with 55 per cent of lead. A crystal of the lead constituent is seen imbedded in the eutectic constituent.

FIG. 4.

FIG. 5.

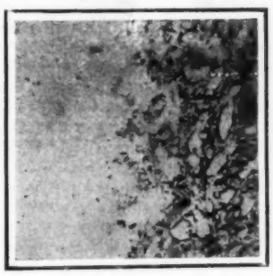


FIG. 6.

Fig. 4.—Eutectic alloy of bismuth and tin, showing the characteristic laminated structure of eutectic alloys. Fig. 5. -The two halves of the figure show the structure of the same kind of brass seen under the same magnification in the case of the two tubes. That represented by the right-hand half of the figure is normal, that of the left-hand half excessively coarsened by undue heating. Fig. 6.—Section through the edge of a piece of "decayed" brass. The section is polished, but not etched, the dark regions being those from which zinc has been removed by corrosive action.

The third class of alloys are those which show a duplex structure. In these bodies the state of mutual solution of the two metals which exists in the liquid state is more or less completely broken up in the solid state; on cooling, the predominating constituent crystallizes out of the fusion until finally the remaining mother-liquor is enriched up to a definite limiting value which is also reached at a definite limiting temperature—then the mother-liquor solidifies in the form which is well known as that of the "eutectic" alloy. The resulting structure of such alloys consists of crystals of the predominating metal imbedded in the "eutectic." The series of lantern slides shown (three of which are reproduced here) serve to illustrate the structures resulting from this mode of solidification of some of the alloys of lead and tin, commencing from an alloy containing only 1 per cent of lead and continuing up to an alloy containing 80 per cent of lead. The manner in which the proportion of eutectic increases to a maximum and then again decreases as the percentage of lead increases, is very evident. I may perhaps add that I have chosen these illustrations from the alloys of lead and tin partly because they have formed the subject of a quite recent research by Mr. P. A. Tucker and myself, but principally because the freezing-point curve of these alloys was given and explained in the Cantor lectures of Roberts-Austen. At that time it was not possible to prepare the softer alloys of this group, viz., those near the lead end of the series, for microscopic examination; no suitable process of polishing had yet been

* Read before the Royal Society of Arts.

discovered. The work of certain eminent French metallographers, principally of Monsieur Henri Le Chatelier, has led to the development of methods of polishing which are applicable, with the aid of much care and delicacy of manipulation, even to the softest metals and alloys. The photographs here shown are examples of the results attained in this way.

The second constituent of the class of alloys just referred to, generally known as a "eutectic" alloy, as has already been mentioned, is an intimate mixture of crystals of the two metals which are present in the alloy. The exact nature and constitution of these bodies, however, presents a number of interesting questions, some of which have yet to be answered. Perhaps the most important of these questions is that of their internal structure. In a large number of cases these eutectic bodies appear to possess a well-defined lamellar structure, such as that shown in the lantern slides (one of which is reproduced in Fig. 4), but it must be borne in mind that such a laminated structure is not necessarily associated with eutectic alloys, and that this form of structure can be readily removed in most cases by suitable heating and cooling processes. All that can be said is that when cooled somewhat rapidly from fusion these alloys tend to assume a laminated structure. But what is this laminated structure? According to one view, put forward by such an authority as Dr. J. A. Ewing, the laminar structure results from a process of oscillatory solidification, minute layers of each constituent solidifying alternately. This view would imply a structure consisting of independent crystals of the two metals juxtaposed in layers. While it cannot be said that this type of structure does not occur in any eutectic alloys, it is certainly not found in a number of typical eutectic bodies which have recently been examined at the National Physical Laboratory. It has been clearly shown in the case of the eutectic alloy of lead and tin, in connection with the research on these alloys already referred to, that the metal consists of crystals of that metal which is present in the largest proportion (by volume as well as by weight), and in the interstices of these crystals—that is in the spaces between the dendritic arms of these crystals—the other metal has been forced to solidify. The actual crystals of tin, in this case, appear to be spherulitic, and large crystals or grains possessing a definite system of crystalline orientation can be recognized. In other eutectic alloys subsequently examined such as the eutectics of copper-silver, bismuth-tin, bismuth-lead, lead-cadmium, bismuth-cadmium, and tin-cadmium, other forms of crystallization have been met with, but the actual structure, as revealed by microscopic methods arranged for this study, is always consistent with the view that the metal present in larger quantity acts a predominant part and forms a crystalline network, in the interstices of which the other constituent is forced to solidify. Quite recently my attention has been drawn by Mr. G. H. Bellby, F.R.S., and by Mr. Sheffield, of Dublin, to the very striking analogy which exists between the detailed forms assumed by laminated eutectic alloys and the forms assumed in certain circumstances by thin films of liquids under the action of surface-tension. Mr. Sheffield has, in fact, sent me a microscopic slide, produced by allowing a liquid, containing fine particles of carbon in suspension, to evaporate on a slip of glass, and the structure of the residual film of carbon is so strikingly like some photo-micrographs of the lead-tin eutectic alloy, that it is difficult to avoid the inference that there must be some analogous forces at work in both cases. Some speculation on this subject offers certain points of interest; thus the play of surface-tension forces may arise from the great softness of the newly-formed dendritic crystals of tin as they exist immediately after their own solidification, and during the solidification of the lead constituent. On the other hand, the work of Quinke suggests that there may be an actual separation of the two constituents, while still in the liquid state, just above the freezing point—a separation into a sort of finely-divided emulsion, the form of each particle, however, being governed by surface-tension forces.

While, at first sight, these questions and speculations as to the intimate nature and mode of solidification of eutectic bodies may appear to be of somewhat academic interest, a little further consideration will show that they involve issues of considerable practical importance. In the first place, it is necessary to bear in mind the fact that a great many most important industrial alloys consist in part of eutectic bodies—steel being one of this group—and that these alloys owe their valuable properties, as apart from those of the pure metal from which they are derived, in large measure to the presence and properties of the eutectic body. These eutectic constituents act as a strengthening, stiffening, and hardening influence on the alloys. But the exact properties of the alloy vary enormously according to the exact condition of the eutectic, and this condition is to be controlled by metallurgists by a correct adjustment of the thermal and mechanical treatment of the alloy, from the moment of its initial solidification onward. The proper methods of such control may be and in fact are to a certain extent ascertained by direct empirical methods—various forms of treatment are tried and that which gives the best results is adopted. But a deeper insight into the internal structure of these eutectic bodies and into their behavior during solidification and under subsequent thermal and mechanical treatment is bound to supplement and extend the empirical knowledge already available and thus serve to extend the control of the metallurgist over the metals he manipulates. Thus, for example, the great influence which the temperature at which a fluid metal is poured into the mold when castings are being produced exerts upon the subsequent properties of the alloy is well known and recognized, and this influence with all its wide-spreading consequences is generally ascribed to "the effect of the rate of cooling." But this is a vague expression and unsatisfactory even in its vagueness, since—in view of the ideas outlined above—it may be quite possible that mechanical agitation of a fluid metal at a temperature very close to its freezing-point may very seriously affect the resulting crystallization—for good or ill. A more intimate knowledge of all that occurs during solidification, and particularly during the freezing of eutectic alloys, may therefore throw much light upon metallurgical processes which are more or less obscure to-day.

The question of the "structural pathology" of metals is a very large one and can only be touched upon in the briefest outline of the present paper. Just as an intimate knowledge of normal anatomy and physiology is essential as a preliminary to the study of pathology, so an intimate knowledge of the "normal" structure of metals is necessary for the diagnosis of disease or "abnormal" conditions. The difficulty in this direction arises from the fact that the internal structures of many metals are almost Protean as regards the changes which they can undergo, and in many cases the variations of properties which accompany these changes of structure find their special applications. The question of the "normality" of a given structure is therefore dependent upon the purpose for which the material is intended.

Broadly speaking, the diseases of metals are of three distinct kinds or classes, according to the nature of the causes which produce them. The first class may be called "diseases of treatment," since they embrace metal which, while of correct composition and otherwise of satisfactory quality, has been rendered weak or unsuitable by the thermal or mechanical treatment to which it has been subjected, either by those who produced it or those who used it. The second class may be termed "diseases of composition," since these arise from the presence in the metal of substances which either should not be there at all or which should only be present in smaller quantities. Finally, the third class includes "diseases of decay" arising from the action on the metal of outside causes, either chemical or mechanical, leading to deterioration. While it is not claimed that microscopic examination will infallibly reveal any or all of these defects, particularly when applied to fragments of some broken object, it is certainly possible in very many cases to obtain microscopic evidence which throws much light on the causes of failure, particularly if the microscopic evidence is systematically correlated with the results of the most exhaustive mechanical tests which can be applied to the available material.

In the space available in the present paper only one or two examples of each of the classes of defects named above can be briefly enumerated. Thus, as regards diseases of treatment, it is sometimes found that steel which has unaccountably failed in practice possesses an unduly coarse structure. As a rule, such a coarse structure results from exposure of the steel to excessive heat, during the forging, welding, or annealing operations to which it has been subjected. In such cases, the microscopic determination of the cause of failure is readily made. Other metals may also possess an unduly coarse structure as a result of improper thermal treatment; thus Fig. 5 shows micrographs of sections from two brass tubes, one of which gave service while the other failed soon after being taken into use. The two photographs are taken at the same magnification and indicate the extent to which the structure of the bad tube has been coarsened by undue heating.

In regard to the injurious influence of impurities it must be said at the outset that examples of failure definitely traceable to this cause are more rarely met with, principally because metallurgical methods render it easier for the manufacturer to eliminate impurities from his products, while chemical analysis has long afforded a means of readily detecting their presence. On the other hand, failures arising from the presence of impurities are unknown. Thus, in commercial steel, and even in the best qualities of this excellent material, inclosures of certain impurities are met with very frequently when the material is examined under the microscope. These impurities are minute globules or thin rods of sulphide of manganese and silicate of either iron or manganese or both. These impurities are ordinarily looked upon as harmless, and in many cases the behavior of test-pieces cut from steel showing these inclosures appears to confirm this view. On the other hand, in such various articles as crank-shafts, gun-tubes and rails, instances have been observed both by the writer and others where the presence of inclosures in steel has, in unfavorable circumstances, led directly to failure in service. Once the fact that the presence of these impurities may act as a source of danger is realized, there can be little doubt that steel-makers will adopt means for their elimination or reduction to safer limits than those occasionally met with in present practice.

Finally, as regards the decay of metals brought about by mechanical or chemical means, a multitude of examples is met with in practice. The majority of these cases, however, arise from the use of unsuitable materials for specific purposes. Thus the "decay" of metals under fatigue, brought about by alternating stresses or vibration, may generally be traced to the employment of either too soft a material or of too small a section, and consequently of too severe a range of stress. The defects arising from corrosion are more difficult to avoid, since the exposure of metals to sea and mine water, and to still more corrosive liquids, cannot always be avoided. But even here a study of the manner in which corrosion occurs in different metals and alloys is interesting and instructive. Thus in the case of brass the mechanism of decay consists in the gradual and progressive removal of the zinc from the metal. In the case of a brass belonging to that range of alloys which possesses a duplex structure, that constituent which is richest in zinc, known as the β constituent, is attacked first and deprived of its zinc, a spongy mass of copper and copper oxide being left behind in the original form of the metal, but, of course, entirely deprived of strength. A section cut through a thick piece of brass in which this removal of the zinc has only penetrated a portion of the thickness of the metal reveals the whole mechanism very clearly. This is illustrated in Fig. 6.

The study of the internal physics of metals by the aid of the microscope is the last aspect of the subject to which reference is to be made here. Again, only the briefest outline is possible.

The fact that both pure metals and alloys are aggregates of minute crystals is now so well established and generally accepted that there is no need to review the evidence here. But the acceptance of the fact that metals are crystalline aggregates immediately raises certain important questions. Thus, most of the industrially useful metals possess in a marked degree the property of plasticity, i. e., they are capable of undergoing very considerable permanent changes of shape without fracture, as, for instance, when a cold bar of steel is bent and twisted into the form of a knot in the manner sometimes adopted for exhibition purposes. To persons accustomed to think of "crystalline aggregates" in connection with such brittle materials as sugar or granite, the suggestion that this pliable metal is also crystalline may at first appear surprising. But, on the other hand, the essential character of crystal-hood, viz., internal molecular symmetry or arrangement, has been shown to exist in materials so soft as to assume a spherical form under the action of surface-tension—bodies which have received the name of "liquid crystals." The plastic metals form a group of wide range between these two extreme classes of crystalline substances, and it may be added that such bodies as glacier ice and limestone rock form intermediate links in the series. The plastic metals, however, lend themselves especially well to the study of the manner in which crystalline aggregates can and do undergo plastic deformation. This process has been clearly shown to consist in the occurrence of a series of very minute slips on some of the gliding or cleavage planes of the crystals constituting the aggregate in question; in this process the minute crystalline elements of which we may conceive each of the actual crystals to be built up, undergo no change of shape, but merely a displacement relatively to their neighbors in the system. In many cases this displacement seems to be a pure movement of translation, but in others it seems that these minute crystalline elements or molecular groups can swing round into alternative positions of symmetry and equilibrium by a process well known to mineralogists as "twinning." In both cases, however, the final result is to leave each crystal still a crystal after permanent deformation, merely differing from its former condition by the displacement of some of its constituent elements, but without any general disorganization of its crystalline arrangement. Experimentally, this process reveals itself if a section of a ductile metal, such as lead or iron, be first prepared for microscopic examination; if such a specimen be subsequently subjected to plastic deformation, the minute slips which occur in the various crystals, appear upon the previously plane surface as minute steps. When viewed with the microscope, under ordinary illumination, these steps appear

as fine black lines or bands, cross-hatching what were previously the plane surfaces of the crystals. The fact that these black lines are really due to steps in the surface, can be demonstrated optically by examining them under light falling upon them at varying incidence, but a still more conclusive proof of their nature has been obtained by the production of an actual cross-section of surfaces upon which these lines or "slip bands" have been previously developed—these cross-sections were obtained by first imbedding the specimen of metal in a deposit of electrolytic copper, and thus protecting the edge of the original surface from injury during the subsequent sectioning process. In these cross-sections the fact that the slip bands are really steps, becomes unmistakably evident.

The microscopic study of metals has thus revealed an important fact in the microphysics of metals and of crystalline aggregates in general. The consequences of this generalization have as yet been worked out only in a few special directions. The most interesting of these is the application of the knowledge of the mechanism of deformation by slip to the explanation of the phenomena of fatigue in metals.

The phenomena of fatigue are, in their general features, so well known that we need only recall here the fundamental fact that under a load or stress which would be quite insufficient to break a given piece of metal if applied steadily and continuously, the same piece of metal will fail after a longer or shorter period of time if the stress be applied in an alternating manner, varying from compression to tension or even varying from zero to its maximum value. The researches of Ewing and Humfrey, subsequently extended and confirmed by the work of Stanton and Bairstow, have furnished the key to these, at first sight, surprising facts. The explanation is based on the recognition of the mechanism of deformation in metals by the process of slip which was briefly outlined above. When a stress is applied to a piece of metal which is still far from sufficient to bring about a general plastic yielding, it may and in fact frequently does happen that owing to want of uniformity in the material or to want of uniformity in the distribution of the stress, a few of the crystals of the metal which happen to be unfavorably situated for meeting this particular stress, yield to it to a slight extent, and this yielding takes place by a small amount of slip occurring in these crystals. If the stress remains constant nothing further occurs, but if the stress be reversed the slip will also be reversed, and this repetition of slip, backward and forward over the same gliding planes, will recur with every alternation of stress. Now when such slipping occurs once only and to a moderate extent, it is sufficiently near the truth to say that the slip occurs without any disarrangement of the crystalline orientation of the molecules, but even then a certain very small amount of disarrangement occurs at the actual surface of slip—the mere rubbing of a piece of cloth over the surface of a piece of metal is sufficient to bring about certain molecular displacements at the surface and to set free temporarily some of the molecules near the surface, allowing them to rearrange themselves in new configurations. In the interior of a metallic crystal, therefore, where sliding occurs under great mutual pressure, some such displacement of molecules lying in or near the surface of slip must also occur.

If the slip only takes place once, the molecules thus disturbed are not only comparatively few in number but they rapidly rearrange themselves in the crystalline system from which they have been temporarily disturbed; if, however, the slip be repeated, not only are the molecules first disturbed prevented from returning to their normal positions, but fresh groups of molecules are disturbed at each repetition, until the continuity of the material is locally destroyed and a fissure is formed—the material has, in fact, disintegrated itself by the continued friction on the surfaces of slip. Nor must this account of the disintegration process be regarded as speculative; the whole process can be followed step by step—the first occurrence of slip in a few isolated crystals and the gradual development of these slips into fissures, followed by the rapid spread of these fissures along the cleavage planes of adjacent crystals, has been followed by the aid of the microscope both in the case of practically pure iron and in steel of various kinds. Consequently it may well be claimed that the mechanism of the mysterious failure of metals under fatigue is now known and well understood.

Within the limits of the present paper it has only been possible to outline briefly and in very general terms some of the more recent achievements of microscopic study of metals and to point out here and there the obvious directions in which further discoveries are to be looked for. To attempt to prophesy the probable course of development of any branch of scientific investigation is always an extremely difficult task, but perhaps enough has been said to show that there is much yet to be learned from the microscopic study of metals. Some of the results to be anticipated are of a directly and purely practical nature; in other cases the lines of inquiry follow more scientific and theoretical directions; but even the most abstract of these questions bear in them—it may be confidently anticipated—the germs of practical applications of the widest importance.

HOW THE SNAKE USES HIS TONGUE.

IS IT A SENSE ORGAN OF DIRECTION?

BY G. R. O'REILLY.

How does the snake find his mate in the woods? How does he find his prey?

Thirty-three years ago I commenced to make a special study of the ways of snakes.

Anyone, who looks closely at a snake, will see that the moment the creature commences to move, he begins putting out his tongue, and keeps putting it out all the time he is moving. Startle him, and its movements become quicker, the tongue is put out oftener. Scare him well and he will keep it out, waving it in the air, for several seconds at a time. Why is this?

The tongue of the snake is long and narrow, and ends in a bifid or bifurcated top; that is to say, it is divided near the top into two long thread-like points. This long thread-like double-pointed tongue is not used for any of the purposes for which we use our tongues. It is not used in swallowing. It is not used in tasting as we understand it. It is not used in voice modulation. It is not used for licking.

What, then, is the tongue of the snake for, if it serves none of the ordinary purposes of the tongue?

I will answer this question shortly, by saying that its extremely sensitive points convey impressions to the consciousness of the snake. But this answer is too vague; it does not explain enough. To my mind the tongue of the snake is a sixth sense. It is similar, in a way, to the antennæ of an insect. It is a feeler, but it is more than that, as we shall see.

Before me, on the table now, is a cage about two feet long, having a glass front. In it is an ordinary garter snake, tame and accustomed to its cage. I take a live toad in one hand, and with the other draw the glass front to one side, opening it far enough to let the toad hop in from my right hand. As the snake first sees my left hand at the glass, he approaches it, expecting to be fed; while he never notices the right hand putting in the toad at the other end. Quickly I push the glass shut. The toad gives a hop forward in the cage, and remains still. The snake does not see the toad. His attention is attracted to my moving fingers pushing the glass back to its place. When I withdraw my hands, he runs his head along the glass from the left over to the right, where the toad entered. His tongue reciprocates inquiringly; but the moment its thread-like tips touch the spot on which the toad first rested, on entering the cage, the behavior of the snake instantly changes. He gets the trail of his prey. He ceases to nose the glass now. He pays no attention to me any more; he lingers over the spot the toad had touched; his tongue-points turn downward, darting in and out unceasingly. For some seconds he thus examines with his tongue tips the whole space on which the toad had rested. When he finds it is not there, he raises his head to look for it elsewhere. His whole body now moves forward; and the toad, affrighted at this gliding terror, makes a jump, landing near a stone farther on in the cage. The snake catches just a glimpse of the quick motion of the toad, and makes a dart toward the place where he saw the moving object, but he fails to catch it. He did not see it perfectly, but he knows it is near, although he sees nothing; and now he becomes very earnest and busy in his search for it. He glides along, examining as he goes, with his tongue tips, the sides and bottom of the cage. The toad rests motionless within two inches of the stone, and yet the snake does not recognize it at rest. The snake comes to the stone, touches it with his tongue; no trail of the toad is on the stone, and he passes on. The toad knows it is not seen, and puts down its head to the floor. It lies there as still as death, for it knows instinctively, that in immobility lies probable safety. The snake passes over it; his belly touches its back as he glides onward, but never a sign of life does the cunning toad exhibit. Presently, the snake, getting no trace of the toad in the further end of the cage, returns. He draws near to the still, motionless batrachian. Aha! this time his tongue tips touch its head, whereupon the toad crouches down closer to the floor. The snake lingers, feeling it with his tongue tips; they tell him here is "toad flavor strong," so he pushes it with his nose to make sure; and the toad, knowing that its ruse of feigning death has failed, gives a jump. This is enough for the snake; he makes a lightning-like dart at it, seizes it, and swallows it quickly. Then he goes back to the spot where the late toad had rested, and examines the vicinity anew, to see if there might perhaps be another toad.

Now in all this proceeding of finding the toad, remember that the snake acts precisely as he would in the woods. He thrusts out his tongue, and touches with its tips every object he meets, till he discovers the trail of his prey. Then he becomes aroused, and looks around sharply. As toads do not travel far, he does not have long to linger over the trail before he sees the creature hop. The tragedy comes to an end by a lightning-like dart and seizure, just as it was done in the cage.

Now the question may be asked, do snakes actually take up the trail of their prey and pursue it in all its windings for considerable distances, using their tongue tips to guide them? To this the answer is that they undoubtedly do.

One instance occurred quite recently. I was sitting at an eastern window of my house in the woods, looking out through the fly screen at a blue-tailed lizard searching for insects among the small chips and bits of bark on the ground outside the kitchen door. The kitchen forms an L from the house, so that I had a full view of the lizard, as he came out from under the kitchen by a pillar and passed within ten feet from the window where I sat. The lizard paid no attention to me, because I was inside the fly screen, and rested motionless, with my elbow resting on the window sill.

I noted accurately the path the lizard took. From the pillar he went to the east of one notable lump of bark, and then diagonally to another, which he passed to the west of, and then off to the other side through a little bunch of weeds, and from that to an empty packing box lying ten feet from me opposite the window. Under the packing box he went, and there he stayed. Casting my eyes toward the kitchen, I saw a blacksnake coming out, at the very same spot by the pillar from which the lizard had come.

He was on the trail, and never swerved from it an inch. He wiggled to the east of the first notable lump of bark, exactly the path taken by the lizard, and to the west of the next, then over to the clump of weeds, and then to the box, passing in, at the very same spot where the lizard had gone two minutes before. He went in under the box farther and farther, till half of him was hidden, and then, all at once, he began to draw himself out backward again. When his head came into view he had the wriggling lizard in his jaws. He swallowed him there and then before my very eyes.

I have seen a king snake trail a blacksnake and devour him in this very way.

Just as this blacksnake carefully trailed up and caught my blue-tailed lizard, so would he trace up and eat a young rattlesnake, if he found its trail in the woods. The gopher snake and the king snake do the same. I have seen them eating rattlesnakes as well as other snakes. I have seen the yellow-tailed South American gopher snake (*Spilotes corais*) trail up and eat a partly grown *fer de lance*, one of the most deadly snakes of the western continent.

The rock temperature in Bendigo mines, according to the report for 1907 of A. H. Marrin, chief mining inspector for Victoria, Australia, increases at the rate of 1 deg. Fah. for each 75 feet below the zone of invariable temperature. At 4,000 feet the temperature due to the heat of the rocks is 110 deg. Fah. At this depth the temperature of the water issuing from the rocks is 114 deg. Fah. Under average underground conditions, when there is water in the downcast shaft, the actual temperature in the stopes will be somewhere between 75 deg. and 110 deg. Fah., depending upon the quantity of air entering the stope and the length of time the air is in contact with the rock before entering the stope.

ENGINEERING NOTES.

Low-grade brown coal, containing much moisture, is sometimes used for heating steam boilers in mining districts, and usually with poor results. The large quantity of water vapor in the furnace gas, which is the heat carrier, acts in two ways to diminish the efficiency—by preventing the acquirement of a high initial temperature and by absorbing a large amount of heat in its formation from the water of the fuel. Experiments recently made in Germany, however, lead to the conclusion that good results may be obtained with fuel of this character by the employment of water-tube boilers designed especially for such fuel, in respect of arrangement of heating surfaces, diameter of tubes, etc.

Many owners of property in San Francisco appear to be dissatisfied with the prohibition of timber construction, and have appealed to the authorities for permission to erect wood-frame buildings merely sheathed with brick or other non-combustible material. The main argument advanced in favor of this retrograde proposal is the well-worn plea of encouraging trade. As brick-veneered buildings of the kind indicated possess very little resistance to earthquake shock, and are not able to withstand the effects of fire much better than ordinary timber structures, it is to be hoped that the city authorities will decide to maintain the existing regulations.

The number of boiler explosions in the United States in 1908, as reported by the Hartford Steam Boiler Inspection and Insurance Company in the Locomotive, was 470. This number compares with 471 in 1907, 431 in 1906, 450 in 1905, and 391 in 1904. The number of persons killed by boiler explosions in 1908 was 281, against 300 in 1907, 235 in 1906, 383 in 1905, and 220 in 1904. The number of persons injured, not fatally, in 1908 was 531, against 420 in 1907, 467 in 1906, 585 in 1905, and 394 in 1904. A record of boiler explosions in the United States kept by the Locomotive for 41 years and 3 months, or since October 1, 1867, shows a total of 10,051, in which 10,884 persons were killed and 15,634 persons were injured.

Sulphate of lime and sulphate of magnesia remain in solution until a temperature of from 300 deg. to 360 deg. F. is reached. In other words, they pass on into the boilers, even though the water be heated previously and filtered, and with the concentration from the boiling off of the water, in time form a hard, porcelain-like scale, difficult to dislodge, and even more dangerous than the soft scale from the carbonates. Apart from the demand for manganese from the steel trade, there is a limited consumption in the preparation of bleaching powder, of oxygen, and of disinfectants. It is further used as a deodorizer in glass manufacture, and also as a coloring matter; but, though for these purposes a specially pure ore of particular composition is demanded and an enhanced price paid, the consumption is relatively so small that it does not affect the manganese industry, so that the demand, and consequently the price, therefore, fluctuates directly with the needs of the steel trade.—School Science and Mathematics.

ELECTRICAL NOTES.

Aluminium wire is not used as extensively as it might be for electric wires owing to the difficulty in making the joints. In Europe only mechanical joints could be used, and these soon become imperfect, whence an increase of electric resistance at the joint. Autogenous welding can now be used by employing the new reducing compound invented by M. Schoop of Zurich. It is not a solder, as such cannot be used with aluminium without forming a galvanic couple and this soon destroys the joint. No foreign metal is employed in the use of the present compound or paste. Dr. Sahulka of Vienna reports that the compound can be used with success. It appears that the joint is as solid as the rest of the metal, according to tests which were made at the Technical College of Vienna.

A new electro-chemical process for extracting zinc from sulphide ores is brought out in Germany by W. Staeger. The ore is first roasted at a low heat so as to form a certain amount of sulphate, and the ore is then treated with dilute sulphuric acid. The liquid contains nearly all the zinc, and it is then freed from other metals by an appropriate treatment. The solution of nearly pure zinc sulphate is then treated by electrolysis in special tanks, using a non-attacked anode surrounded by a porous covering, and a cathode of thin sheet zinc. The zinc obtained in this way is very pure and the bath is readily kept constant by the proper additions of material. Where current can be obtained cheaply from a hydraulic plant, the present process can be used to a great advantage, especially in extracting zinc from low-grade sulphurous ores which are not adapted to be economically treated by the distillation process.

The influence of daylight on the range of spark-telegraph stations is discussed by Mosler in Elektrotechn. Zeitschr. He first cites the views held by Marconi, J. E. Taylor, and J. J. Thomson as to the cause of the pronounced absorption noticed in the daytime as compared with the night. Zenneck's recent theoretical investigation would tend to favor Marconi's view as to the effect being due to a photo-electric influence. Mosler has now carried out experiments on the damping in the antenna at various times of the year and of the day or night with a view to obtaining further data. Sending between Brunswick and Berlin (200 kilometers), the intensity of the signals and the range through which the variable condenser had to be varied in order that the signals should vanish remained constant at both places. Between Brunswick and Norddeich, similarly, there was no detectable alteration. The Poldhu signals, however (1,100 kilometers from Brunswick) were markedly weakened by daylight as compared with the night signals. Mosler concludes that it cannot be a question of the transmitting station being influenced by daylight, as in such a case the effect would be noticeable at shorter distances, and he inclines to the view that with long-distance transmissions the propagation takes place in the higher strata of the atmosphere, where the ionization is of sufficient magnitude to cause the absorption.

TRADE NOTES AND FORMULÆ.

Ink for Rubber Stamps.—For this purpose castor oil and a coloring substance, soluble in oil, is especially adapted. This latter must, however, be rubbed down with a little oleic acid before adding it to the oil. Red: 15 parts of Bordeaux red, 15 parts aniline red, 45 parts crude oleic acid, 1,000 parts of castor oil, which should be heated to not more than 110 deg. F. Blue black: 5 parts of aniline black, 6 parts crude oleic acid, 100 parts castor oil. Violet: 3 parts aniline violet, 5 parts oleic acid, 100 parts castor oil.

Vanadium Ink.—Tannin or gall-nut decoction produces, with vanadinate of ammonium, a deep blue-black precipitate. It is so finely distributed in the fluid that even after standing several days it does not settle, especially if the density of the fluid be increased by Senegal gum. The following are suitable proportions: 10 parts tannin, 0.2 part vanadinate of ammonium, 200 parts of water, 6 parts of gum. Pyrogallic acid gives a deep blue-black fluid (without precipitate) which is especially suited for steel-pen inks. Logwood extract used with the same proportions of vanadinate of ammonium, as with tannin, also yields an excellent ink.

Iridescent Paper.—According to Harry and Musgrave's patent, the following mixtures should be prepared: I. A solution of tannic acid in water, for instance, a decoction of 30½ parts of powdered gall nuts, in 122 parts of water. II. A steeped mass of sea moss (Iceland moss in water is best), 30½ parts of moss in 306 parts of water. These solutions are mixed and any desired quantity of lightproof coloring matter added (cobalt blue, saffron yellow, or logwood extract), according to the tint it is desired the paper should have. With this mixture, the paper is to be coated in the most convenient manner, and in sheets or an endless strip, it is transferred to an apartment in which it is exposed to ammonia fumes; after leaving the fuming apartment, it is quickly dried and calendered. As a result of the action of the ammonia fumes on the applied coating, an exceedingly delicate, iridescent film is formed. According to the Roudillin patent, the following mixtures are applied to the paper: 7 parts nitrocellulose, 681 parts 95 per cent alcohol, 295 parts ethyl ether, 13 parts benzole, 2.7 parts rosin, 0.7 part mastic, 0.6 part rape oil, or 2.4 parts nitrocellulose, 275 parts acetate of amyl, 564.5 parts of rosin, 15 parts mastic, 0.6 part rape seed oil. In some cases nitrocellulose and benzine, or the benzine alone, may be omitted from the second recipe.

Fireworks and Bengal Papers.—Firework papers, on burning, produce a shower of sparks and resemble fire-work sheaves. According to Vilon, they are made from an unsized paper, covered with a melting coating. The following compositions are used: I. Flour powder 10 parts, hardwood charcoal 2 parts, flax-meal powder 5 parts. II. 100 parts flour meal powder, 2 parts sulphur, 20 parts zinc filings, 50 parts flax-meal powder. III. 100 parts flour powder, 5 parts sulphur, 20 parts iron filings or antimony, 50 parts of flax-meal powder. The paper is coated with these compositions and allowed to dry in the dark at ordinary temperature. To conceal the composition of the mass, the papers can be covered by pasting on colored paper. Bengal papers, on burning, show different colored light, like the Bengal fires. To make the paper, which is best when rolled up, unsized paper is dipped in an aqueous or alkaline solution of suitable metal salts. Red flames: 10 parts water, 2 parts each of alcohol and nitrate of strontium, 1 part chlorate of potash. Green flames: 10 parts of water, 2 parts each of alcohol and chloride of barium. Yellow flames: 10 parts of water, 2 parts of alcohol, and 1 part each of chlorate of potash and oxalate of sodium. Blue flames: 10 parts water, 2 parts each of alcohol and chlorate of copper, 1 part chlorate of potash. Violet flames: 100 parts water, 50 parts of alcohol, and 15 parts each of chlorate of strontium, chlorate of copper, and chlorate of potash. Lilac flames: 10 parts of water, 5 parts of alcohol, 2 parts of chlorate of potash, and 1 part each chlorate of copper and chloride of strontium.

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